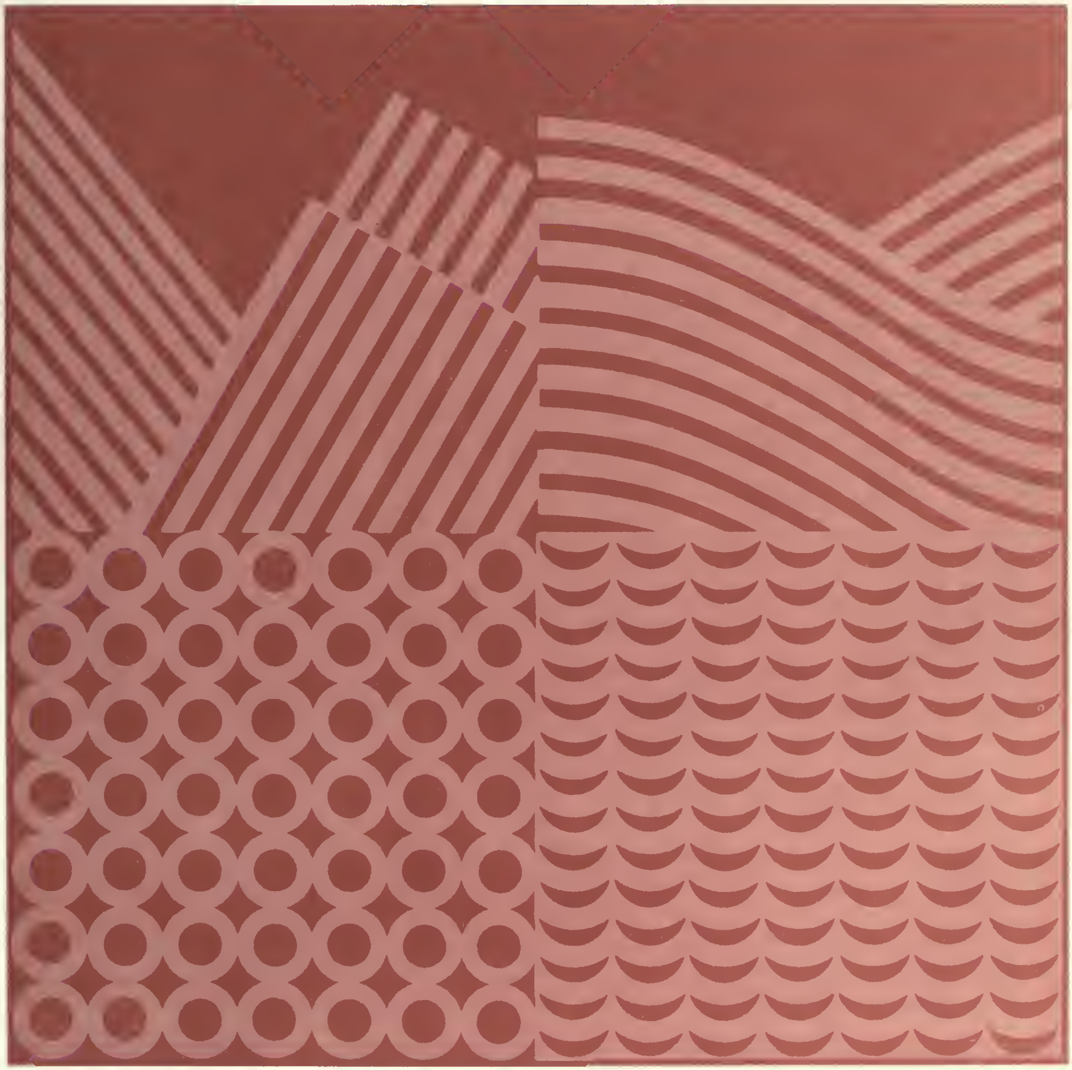
Tongue River, Montana, Petition Evaluation Document

Draft

82–4–228 SUMRA and
522 SMCRA Evaluation
DSL/OSM–PE–2

State of Montana
Department of State Lands

U.S. Department of the Interior
Office of Surface Mining Reclamation and Enforcement



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September 1981

Prepared by the
Montana Department of State Lands and the
U.S. Office of Surface Mining Reclamation and Enforcement
in cooperation with the U.S. Geological Survey and
the Montana Bureau of Mines and Geology

James R. Harris, Director
Office of Surface Mining
Reclamation and Enforcement

Gareth C. Moon, Commissioner
Montana Department of State Lands

COVER SHEET

A. TITLE OF DOCUMENT

Tongue River, Montana, Petition Evaluation Document

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Comments on this document should be submitted to the Montana Department of State Lands at the above address before 5 p.m., October 30, 1981. The final document is anticipated to be a supplement to this draft document; therefore, **please retain the draft evaluation document to use with the final.**

C. ABSTRACT

The Northern Plains Resource Council filed the Tongue River petition on December 29, 1980, with both the Montana Department of State Lands and the Office of Surface Mining Reclamation and Enforcement. The petition alleges (1) that the area is nonreclaimable, and (2) that surface coal mining could result in substantial loss or reduction of long-range productivity of renewable resource lands, including water supply and food products, in the affected area.

This evaluation document presents analyses of the recoverable coal resources within the petition area, of the soil resource and its reclaimability, and of the cumulative impact of mining to the water resource both within and downstream from the petition area.

The area extends from 1 mile west of Wall Creek (south of Birney) to 1 mile north of Beaver Creek (near Brandenberg) along the Tongue River, and southeast along Otter Creek to 2½ miles south of Fifteenmile Creek. The approximately 194,650-acre petition area is bounded on the east and on the south by Custer National Forest and on the west by the Northern Cheyenne Indian Reservation.

The various alternatives analyzed include: designating the area as unsuitable for coal mining; not designating the area as unsuitable for coal mining; or restricting levels, types, and methods of mining to those which would assure reclaimability or would assure no loss or reduction in the long-range productivity of renewable resource lands.

This document was jointly prepared by DSL and OSM. A final decision on this petition by the Commissioner of the Montana Department of State Lands and the Director of the Office of Surface Mining is required by December 22, 1981.

SUMMARY

A. BRIEF EXPLANATION OF THE PETITION PROCESS

Those criteria for assessing unsuitability for surface coal mining operations provided by SUMRA, Section 82-4-228(2), MCA, and by SMCRA, Sections 522(a)(3)(B) and 522(c), include nonreclaimability, incompatibility with existing land use plans, potential damage to fragile or historic lands, substantial loss or reduction of long-range productivity of water supply or food or fiber products, and mining on hazardous lands which could endanger life or property.

B. DESCRIPTION OF THE TONGUE RIVER PETITION

Events.--The Tongue River petition was originally submitted November 26, 1980, and was formally rejected by the Montana Department of State Lands (DSL) and the Office of Surface Mining Reclamation and Enforcement (OSM) on December 19, 1980. The reasons for rejection included (1) failure to establish that saline and sodic conditions extend throughout the petition area and (2) discrepancies between the map submitted and the legal description identifying the petition area. The Tongue River petition was refiled with DSL and OSM on December 29, 1980, and was determined to be complete on January 19, 1981. **Public hearings on the petition and the draft evaluation document are planned for October 21 and 22, 1981, from 6 p.m. to 10 p.m. in Ashland, and the final decisions on the petition are anticipated in December 1981.** Public notice of the hearing will be distributed in mid-September.

Issues.--The major allegations of the petition are:

(1) The area affected by surface coal mining operations could not be reclaimed in accordance with the requirements of the act (i.e., the soils are too thin and salty to be reclaimed successfully); and

(2) Surface coal mining operations in the affected area would result in a substantial loss or reduction of long-range productivity of the water supply and of food and fiber products (i.e., the cumulative impact of mining on water would be serious, permanent, and deleterious).

C. DEFINITION OF STATE AND FEDERAL ACTION

The Commissioner, Montana Department of State Lands, for private and State lands, and the Director, Office of Surface Mining, for Federal lands, are required to make decisions on the Tongue River petition by December 22, 1981.* In the event that the Commissioner and the Director disagree as to the decision, each would make the final decision for non-Federal and Federal lands, respectively.) The

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*As part of the regulatory review, OSM intends to propose revised regulations for 30 CFR, Parts 760-769. The State regulatory authority (DSL) will be afforded the opportunity to modify these regulations accordingly. These regulatory changes will not affect the petition. This petition will be processed according to current State and Federal regulations.

several alternatives available to them range from designating all lands in the entire petition area as unsuitable for all or certain types of surface mining operations, to not designating any of the lands in the area as unsuitable. The decisionmakers also have the option of designating only parts of the area as unsuitable for all or certain types of surface coal mining operations. The action alternatives are as follows:

- o Designation that the entire petition area is unsuitable for surface coal mining operations.--No new permits for coal mining that would affect the surface could be issued in the area designated, and the area would be withdrawn from Federal coal leasing.

- o Designation that none of the petition area is unsuitable for surface coal mining operations.--The normal State and Federal Lands Regulatory Programs would apply to surface coal mining activities. A determination to not designate any or all of the petition area as unsuitable does not mean that coal mining would necessarily occur. Coal mining operations could commence within the petition area only upon approval of a site-specific mine plan. Montana law allows DSL to selectively deny mining in certain critical, fragile, or unique areas after DSL has received an application to mine such areas.

- o Conditional designation of unsuitability.--Decisions could also be made making partial designations of unsuitability, such as declaring certain types of coal mining as unsuitable, or certain locations as unsuitable, or a combination of both, as follows:

  - o Designate as unsuitable for all surface mining operations those parts of the petition area on which reclamation is not technologically and economically feasible.

  - o Impose conditions on future mining operations in order to protect the water resources of the Tongue River.

- o Designate the entire petition area as unsuitable for surface mining, but allow underground mining. This decision would be made provided that mining and related impacts do not result in significant surface disturbance.

D. PUBLIC RECORD

A public record is available at the DSL Offices: 1625 - 11th Avenue, Helena, Montana, and 1245 North 29th Avenue, Billings, Montana; and at the OSM Office: Brooks Towers, 1020 - 15th Street, Denver, Colorado. This record may be reviewed and any portion of it may be copied at a reasonable charge. Included in this record will be the data specifically generated for this project, as well as the petition, supporting affidavits, interventions, and petition-related documents.

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CHAPTER I.

INTRODUCTION

A. SCOPE OF EVALUATION

The Surface Mining Control and Reclamation Act (SMCRA), Section 522(c), and the Montana Strip and Underground Mine Reclamation Act (SUMRA), Section 82-4-228, MCA, provide for a process by which citizens may petition to have an area designated as unsuitable for all or certain types of surface coal mining operations. The report of the Committee on Interior and Insular Affairs, H.R. Report No. 95-218, April 22, 1977, discusses the purpose of the unsuitability designation process:

> "The process for designation of land areas as unsuitable for surface coal mining is also premised on the notion that successful management of surface mining depends, in large part, on the application of rational planning principles. While coal surface mining may be an important and productive use of land, it also involves certain hazards and is but one of many alternative land uses. In some circumstances, therefore, coal surface mining should give way to competing uses of higher benefit * * *.
>
> "The committee wishes to emphasize that this section does not require the designation of areas as unsuitable for surface mining other than where it is demonstrated that reclamation of an area is not physically or economically feasible under the standards of the act. The other criteria for designation, which related to general planning and environmental concerns, are discretionary and thus the State could determine that no lands should be designated thereunder, or, on the other hand, could prohibit all or some types of surface mining entirely. In addition to the discretionary designation criteria, the designation process included other elements of flexibility. For example, the designation of unsuitability will not necessarily result in a prohibition of mining. The designation can merely limit specific types of mining and thus the coal resource may still be extracted by a mining technology which would protect the values upon which the designation is premised. In addition, after an area is designated, coal development is not totally precluded, as exploration for coal may continue. Moreover, any interested person may petition for termination of a designation.
>
> "The designation process is not intended to be used as a process to close existing mine operations, although the area in which such operations are located may be designated with respect to future mines * * *.
>
> "It should be noted that the designation process is structured to be applied on an area basis, rather than a site-by-site determination which presents issues more appropriately addressed in the permit application process. The committee believes that the area-by-

area approach of Section 522 thus serves the industry since such a process may, in advance of application, identify lands which are either not open to surface mining or where surface mining is subject to restrictions."

It should be clearly understood that a decision to not designate all or any part of a petition area as unsuitable for all or certain types of surface mining operations would not mean that such lands are, conversely, determined as suitable. The designation process as discussed by Congress is not intended to usurp the permitting and mining plan requirements.

Any area designated as unsuitable for surface coal mining operations may be petitioned to have such designation terminated (30 CFR 764.13(C) and 769.13(b) and Section 82-4-28, MCA). The petition to terminate must include allegations with supporting evidence, not contained in the record of the proceedings in which the area was designated as unsuitable.

Should this Tongue River petition not be granted, or be only partially granted, subsequent petitions with allegations of facts and with supporting evidence not included in the proceedings of this petition are possible. The evaluation of this petition does not attempt to develop allegations beyond those in the petition. There were requests to prepare an environmental impact statement that would, to the extent possible, examine all identifiable issues. The purpose, of course, would be to reduce the possible delays caused by subsequent petitions. The Montana Department of State Lands (DSL) and the Office of Surface Mining Reclamation and Enforcement (OSM) declined these requests after determining that it was impossible to both develop and, more importantly, identify all possible issues within the statutory decisionmaking timeframes for designation petitions set by State and Federal law.

The Tongue River petition was filed with the Montana DSL and with OSM on November 26, 1980, by the Northern Plains Resource Council (NPRC), the Tri-County Ranchers Association, the Rosebud Protective Association, and the Tongue River Agriculture Protection Association. This petition was formally rejected on December 19, 1980. The reasons for rejection included (1) failure to establish that saline and sodic conditions extend throughout the petition area and (2) discrepancies between the map submitted and the legal description identifying the petition area. The petition was revised by NPRC and resubmitted December 29, 1980. DSL and OSM deemed this resubmission complete on January 19, 1981.

Lands within the petition area (figs. I-1, I-2, I-3, I-4) include Federal, State, and fee (private) lands. The petition area contains no presently leased Federal coal; however, expressions of interest for the BLM's proposed 1982 lease sale have come from Wesco Resources, Consolidation Coal Co. (Consol), Coal Creek Mining Co., and Burlington Northern. There are several existing fee and State coal leases within the petition area held by Peabody Coal, Carter Oil Co., Consol, Amax, Fred Woodson, and Montco. There is one existing mine on fee coal within the petition area, the Coal Creek mine, located in the N½ sec. 3, T. 3 S., R. 45 E. In addition, the State of Montana has received an application for a proposed mine on fee coal within the petition area (fig. I-4) from Montco. This application is currently under review by DSL, although no permit decision can be made on the application until a decision has been made on the Tongue River petition. The processing of this petitiion has not, to date, held up the processing of this mine permit application.

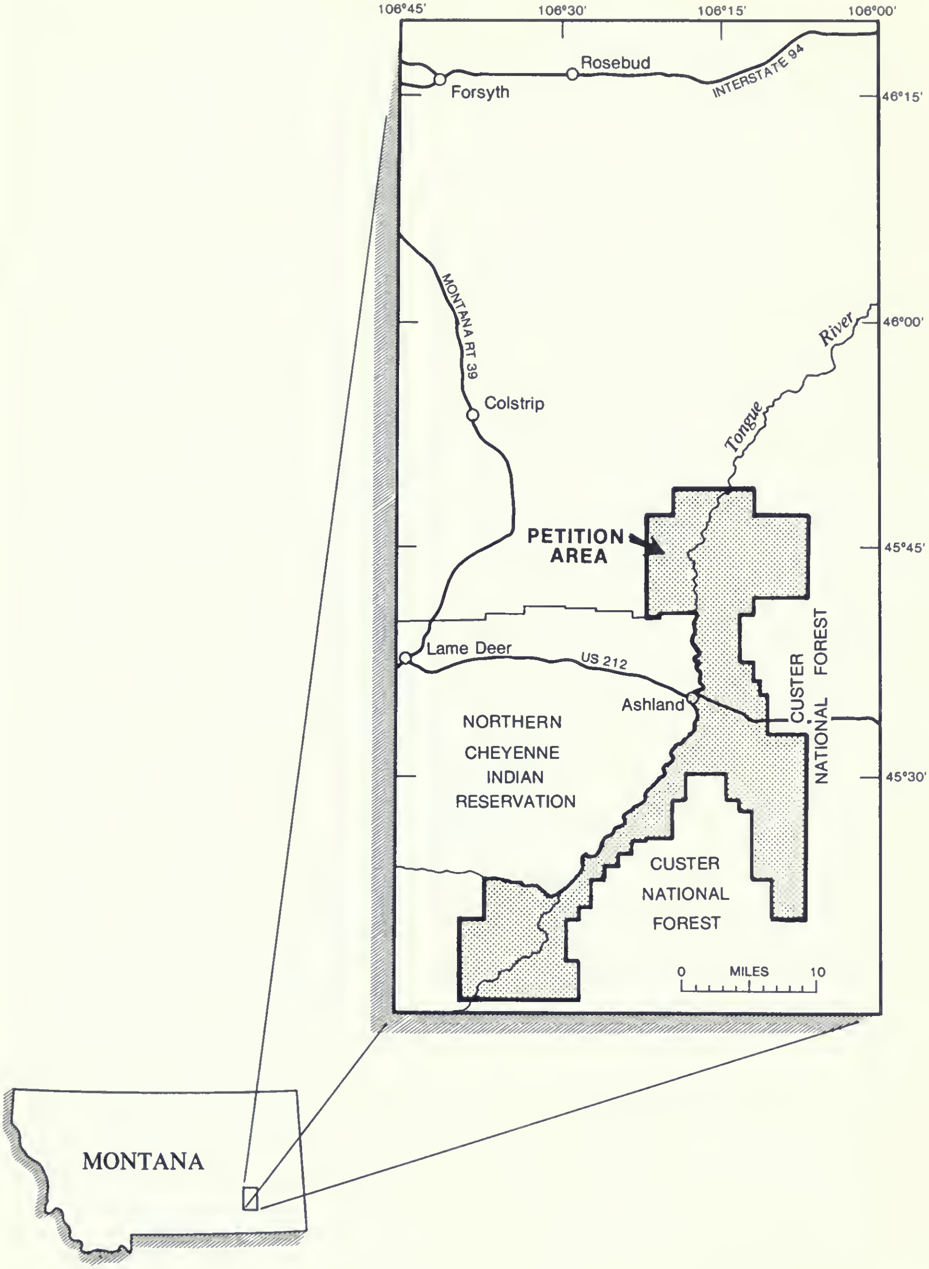

Figure I-1.--Location of lands within the petition area.

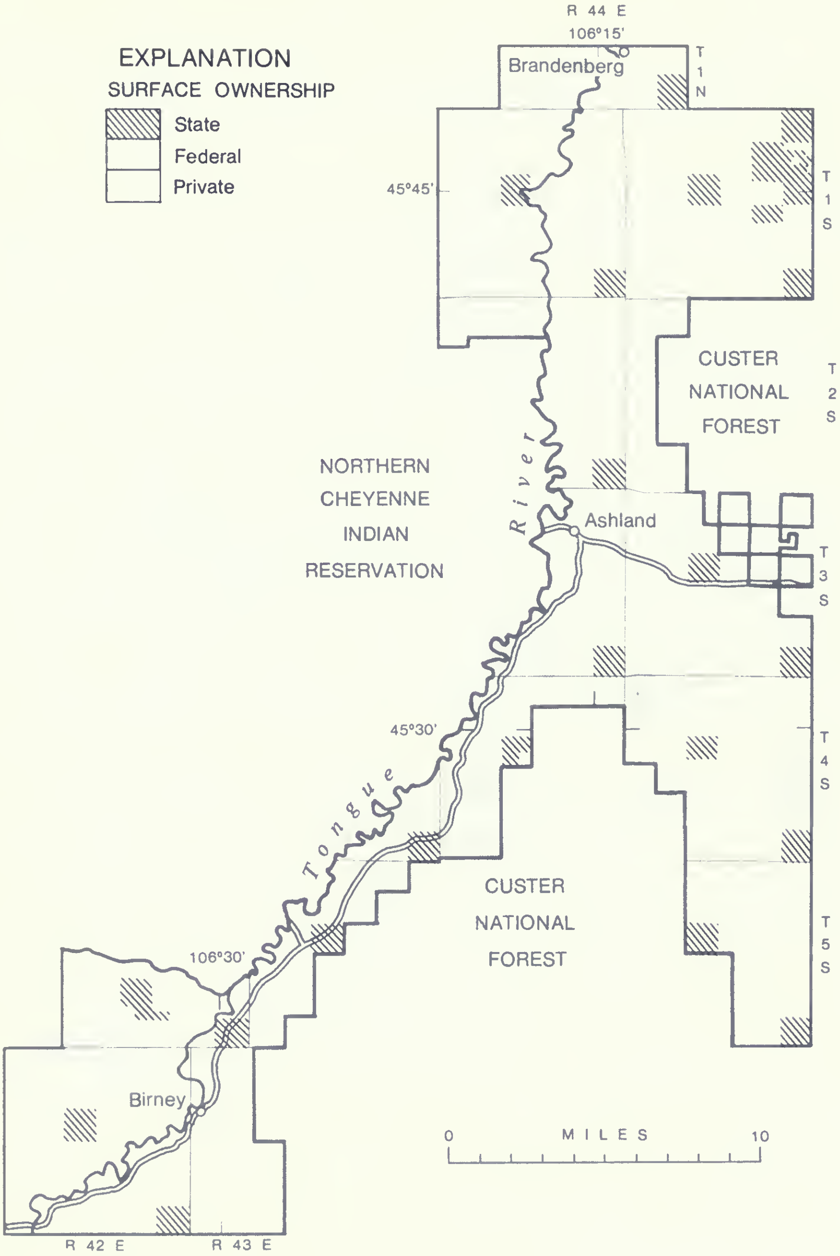

Figure I-2.--Surface ownership within the petition area.

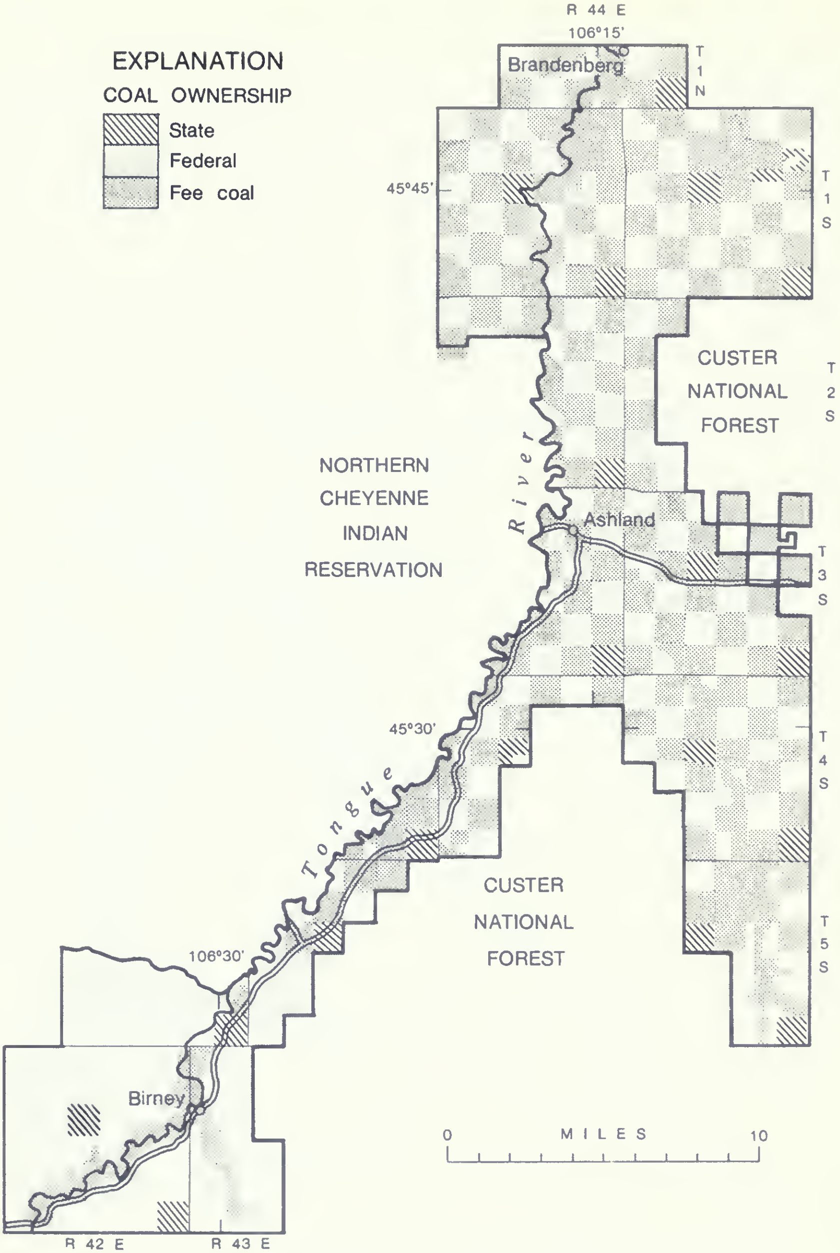

Figure I-3.--Coal ownership within the petition area.

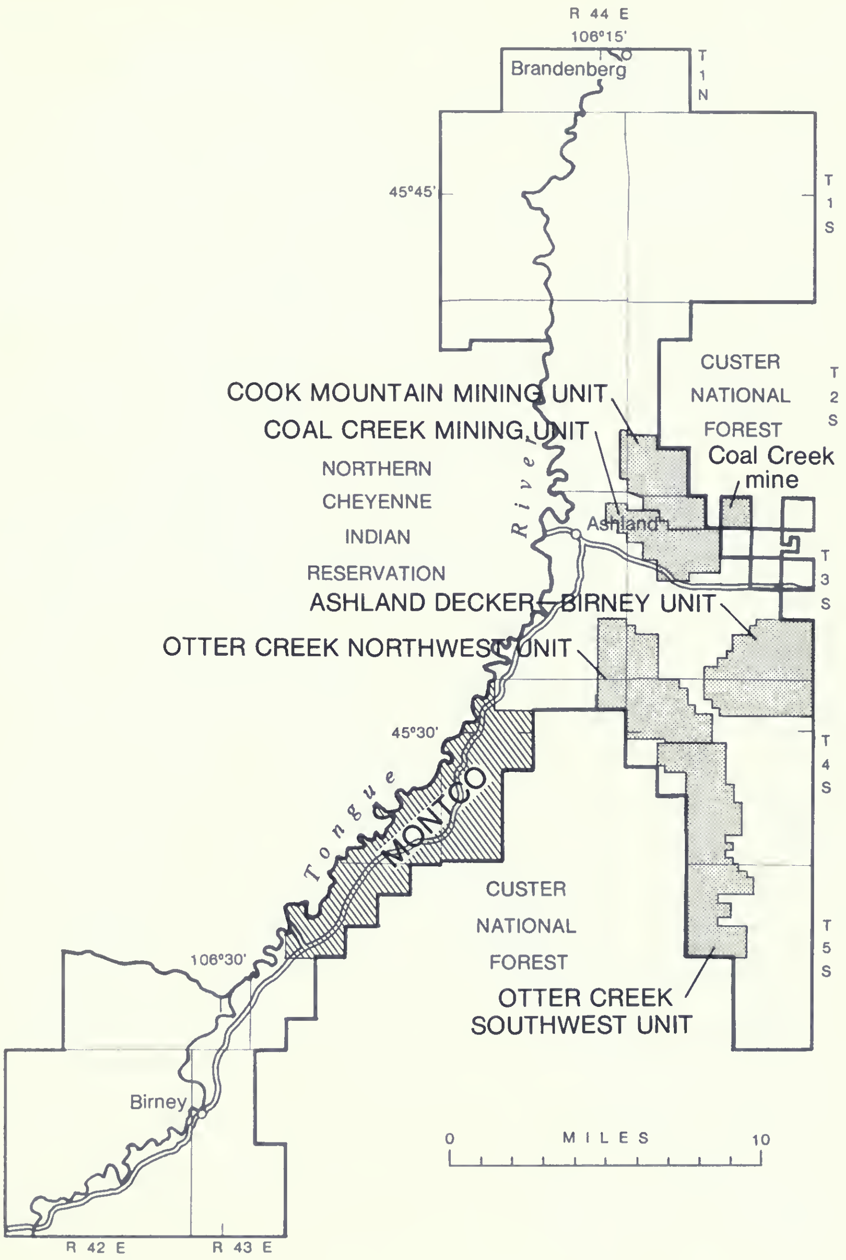

Figure I-4.--Location of the 1982 BLM leasing tracts, the Coal Creek mine, and the proposed Montco mine.

This document combines an evaluation of the allegations in the petition, which requests designation of both Federal and non-Federal lands as unsuitable for surface coal mining operations, with an environmental assessment of the possible effects on the petition area resulting from any Federal and/or State actions. This combined evaluation and assessment has been made to avoid duplication and to reduce paperwork. Copies of the petition are available, on request, from the Montana DSL at the address on the cover sheet.

DSL and OSM developed potential mining levels on which to base the evaluation of the petition allegations because no mining is presently proposed for the greater part of the petition area. For assessment purposes, the allegations made in the petition have been categorized into disciplines for assessment. Assessments in this document assume that all applicable Federal and State laws, rules, regulations, and land use plans would be in effect. The adverse impacts described herein would not be mitigated by normal site-specific measures. Impacts are categorized as short term when they would occur only during the life of mining and reclamation (about 40 years) and as long term when they would exist after mining and reclamation have been completed.

Those studies not completed prior to the release of this draft document are presented in as great a detail as possible and will be completed prior to and used in preparing the final document. In addition to the use of all available data, statements submitted in support of the petition, were considered in the analysis.

In many instances, there is clearly a lack of detailed soils and hydrologic data for the petition area which would have greatly assisted the agencies in evaluating the allegations. Such detailed data are usually acquired over a period of many years. Detailed site-specific data are required from coal companies as a part of their mine application. The mandatory 1-year time limitation given DSL and OSM to reach a decision on the petition's allegations of unsuitability precludes the collection of significant new data as a part of the petition analysis process. Furthermore, the baseline data utilized in this document are not sufficient for making, nor is it intended to make, the site-specific mining and reclamation plan decisions required by SUMRA and SMCRA.

B. PETITION CRITERIA AND EVENTS

Those criteria for assessing unsuitability for surface coal mining operations provided by SMCRA, Section 522(a), and SUMRA, Section 82-4-228(2), MCA, include nonreclaimability, incompatibility with existing land use plans, potential damage to fragile or historic lands, substantial loss or reduction of long-range productivity of water supply and/or food or fiber products, and mining on hazardous lands which could endanger life or property. The Tongue River petition alleges that the area is nonreclaimable and that surface coal mining could result in substantial loss or reduction of long-range productivity of renewable resource lands including water supply and food and fiber products.

Timeframes for the decision on this petition are established by Section 522 of SMCRA and Section 82-4-228 of SUMRA. A public hearing on the petition must be held within 10 months of receipt of the petition, and decisions must be made within 60 days of the public hearing, a maximum of 12 months from the receipt of a complete petition.

The Tongue River petition was filed with DSL and OSM on December 29, 1980, and was determined to be complete on January 19, 1981. Public hearings on the petition and the draft evaluation document are planned for October 21 and 22, 1981, in Ashland, and the final decisions on the petition are anticipated in late December 1981. Notice of the hearing will be published in local newspapers and in the Federal Register in mid-September and will be mailed to those who have expressed an interest in the petition.

This draft document is not required by either SMCRA or SUMRA but is being released at this time to better allow for public participation in the unsuitability process. It is hoped that all recipients of this document will review it in detail prior to the public hearing at the end of October and provide written comments either at that time or at any time prior to November 2, 1981. Comments not submitted at the hearing should be sent to Sandi Johnson at the Montana DSL address shown on the cover sheet of this document. All persons wishing to submit comments are encouraged to do so as soon as possible.

C. PETITIONERS AND PETITION ISSUES (ALLEGATIONS)

This petition was submitted by four organizations: the Northern Plains Resource Council (NPRC), the Tongue River Agriculture Protective Association (TRAPA), the Tri-County Ranchers Association (TCRA), and the Rosebud Protective Association (RPA).

Their petition alleges that:

1. The area affected by surface coal mining operations could not be reclaimed in accordance with the requirements of the act. This allegation is further detailed by statements that reclamation is not technologically or economically feasible because of a combination of sodic and/or salty soils and shallow recoverable topsoils. The petitioners further allege that the physical and chemical properties of soils and overburden are inadequate for revegetation. Statements in support of this general allegation are as follows:

    a. The petitioners allege that salt and sodium problems are widespread throughout the petition area. Salt and sodium levels at some sites are extraordinarily high.

    b. The petitioners allege that well over 50 percent of the soils are too shallow for recovery.

        They further allege that soils in the area appear to be dominated by smectite clays, which are highly sensitive to exchangeable sodium, thus aggravating the adverse effect of an already serious problem. High levels of exchangeable sodium concentrations in the soil and overburden would have adverse effects on both plant growth and soil structure. The petitioners state that mining activities would release salts from overburden strata, which would further add to the saline and/or sodic conditions of the area, and that the upward migration of salts and sodium would be exacerbated.

c. The petitioners allege that climatic characteristics of the area would further impede successful revegetation. Under the semi-arid (14 inches annual rainfall) conditions in the petition area, migration of salts and sodium would tend to be in an upward direction, resulting in high concentrations of these materials in the root zone and on the soil surface.

d. The petitioners allege that the shortage of salt-free topsoil available to bury sodic/saline material presents a technological obstacle to successful reclamation. Even with sufficient suitable materials for burying sodic spoils, the necessity of hauling water, adding soil amendments, and providing drainage to counteract the sodium problems would be prohibitive.

e. The petitioners allege that the effects of salt translocation often take decades to manifest themselves. Evidence indicates that burial of salty or sodic material by relatively nonsaline topsoil may only postpone consequences. Surface mining and reclamation technology is too recently developed to assess effects of burying sodic materials.

f. The petitioners allege that the combination of poor soil structure and the lack of vegetative cover, which would result if reclamation fails, would increase susceptibility of soils to wind and water erosion.

2. Surface coal mining operations in the affected area would result in a substantial loss or reduction of long-range productivity of the water supply and of food and fiber products. More specifically, the petitioners allege that they would be adversely affected by the decline in the quality of surface water and ground water in the petition area and adjacent downstream areas, and that they would be adversely affected by the erosion and the increased sediment load in streams as a result of not being able to reclaim surface-mined lands in the petition area. Statements in support of this general allegation are as follows:

a. The petitioners allege that large-scale mining in the petition area would cause significant regional changes. Most of the shallow ground water in mined areas, plus part of the downstream regions, would be of marginal use for stock and undesirable for other uses. Deterioration of marginal aquifers and degradation of water in the Tongue River alluvium would destroy the agricultural productivity of the affected areas.

b. The petitioners allege that the effects on Tongue River water quality from large-scale mining in the petition area would appear gradually over a period of years and become observable only after it is too late to remedy the damage or cause. Water-quality degradation from surface mining along the Tongue River would continue for hundreds of years.

c. The petitioners allege that reduced streamflows in the Tongue River, which would result from climatic conditions and increased withdrawals upstream for irrigation, municipal, or industrial uses, would accelerate the decline in water quality.

d. The petitioners allege that mines upstream from the petition area, both ongoing and likely additional operations, would compound the deleterious effects on the Tongue River caused by mining in the petition area.

e. The petitioners allege that if reclamation fails in the petition area, increased sediment loads might result which would further degrade water quality in the Tongue River.

f. The petitioners allege that the intense pressures on the Tongue River upstream from the petition area and the significance of the petition area as a source of recharge, transmission, and discharge of ground water accentuate the critical importance of preserving the area from the disruptive effects of surface mining.

D. SUMMARY OF INTERVENTIONS

The designation of lands process allows for interested parties to intervene by filing allegations of facts which support or refute the petitioners' allegations. DSL and OSM have received several interventions to date and will accept interventions until 3 days prior to the public hearing, thus, on or before October 18, 1981. Those interventions submitted prior to August 19 are considered in this draft evaluation document. All interventions will be considered in the final petition evaluation document. The final document will consider information submitted with interventions, and other relevant documents, in the technical analysis of the petition's allegations. Each intervenor's allegations may not, however, be addressed on an individual basis.

Applications for interventions have been received from the following parties: Burlington Northern, Inc.; Wesco Resources; Montco; and Marcus L. Nance IV, Jay T. Nance, Susanne W. Boedecker, Nance Cattle Co., The Brown Cattle Co., Arthur F. Hayes, Sr., and Nancy B. Hayes. In addition, several individuals have submitted affidavits and comments. All interventions, affidavits, and correspondence are on file in the public record in DSL's Helena and Billings offices and OSM's Denver office.

E. PROPOSED FEDERAL AND STATE ACTIONS

The Commissioner, Montana DSL, and the Director, OSM, are required to make decisions on the Tongue River petition no later than December 22, 1981. Several alternatives are available to the decisionmakers, ranging from designating all lands in the entire petition area as unsuitable for all or certain types of surface mining operations, including any conditions of mining operations, to not designating any of the lands in the area as unsuitable. The decisionmakers also have the option of designating parts of the area as unsuitable for all or certain types of surface mining operations. Although total compliance with regulations or approval of specific mining plans and permits do not guarantee the avoidance of impacts, monitoring and enforcement of the requirements by the regulatory authorities will ensure that the effects of mining on the environment are minimized.

Several alternatives are analyzed in chapter V. They are:

1. Designate the entire petition area as unsuitable for surface coal mining operations. Under this alternative no new permits for coal mining that would affect the surface could be issued in the area designated, and the area would be withdrawn from Federal coal leasing.

2. Designate none of the petition area as unsuitable for surface coal mining operations. The normal State and Federal Lands Regulatory Program would apply to surface coal mining activities. A determination to not designate any or all of the petition area as unsuitable does not mean that coal mining would necessarily occur. Coal mining operations could commence within the petition area only upon approval of a site-specific mine plan. Montana law additionally requires DSL to selectively deny mining in certain critical, fragile, or unique areas as a part of its review process for specific minesites.

   This alternative would comply with the NEPA and MEPA requirements to analyze a no action alternative.

   Decisions could also be made making partial designations of unsuitability, such as declaring certain types of coal mining as unsuitable, or certain locations as unsuitable, or a combination of both. The alternatives that have been considered or analyzed follow:

3. Conditional designation of unsuitability.

4. Designate the entire petition area as unsuitable for surface mining, but allow underground mining.

F. CONTROLLING LEGISLATION

Surface Mining Control and Reclamation Act and the Montana Strip and Underground Mine Reclamation Act

Section 522 of the Surface Mining Control and Reclamation Act (SMCRA) of 1977, P. L. 95-87; 91 Stat. 445 and 507; 30 U.S.C. 1272, authorized the Secretary of the Interior to utilize rational land use planning principles to determine whether surface coal mining should be prohibited due to "competing uses of higher benefits" (H. R. Report No. 95-218, 95th Congress, 1st Sess. 94 (1977)). The State of Montana enacted the Strip and Underground Mine Reclamation Act (SUMRA), Section 82-4-228, MCA, with similar statutory provisions. Instead of complete prohibition of mining, designation may simply limit certain types of surface mining methods. Designation informs the mining industry at an early date that the lands either are not open to surface mining or are subject to significant restrictions.

Pursuant to both the Federal and State unsuitability provisions, any person who is or may be adversely affected may petition the respective regulatory authority to designate lands as unsuitable for for surface coal mining if those mining operations would (1) not be technologically and economically feasible to reclaim, (2) be incompatible with applicable existing State or local land-use plans, (3) affect fragile or historic lands in which mining could cause significant damage to important historic, cultural, scientific, and esthetic values and natural systems,

(4) affect renewable resource lands on which such operations could result in a substantial loss or reduction of long-range productivity of water supply or of food or fiber products (including aquifers and recharge areas), or (5) affect natural hazard lands, thus endangering life or property (SMCRA, Section 522(a)(3) and SUMRA, Section 82-4-288, MCA). The petition for such designation must contain allegations of fact and supporting evidence which would tend to support the allegations (SMCRA, Section 522(c) and SUMRA, Section 82-4-228, MCA); the location and size of the petition area; a description of how mining may adversely affect people, land, air, water, or other resources; the petitioner's name, address, and telephone number; and identification of the petitioner's interest that is or may be adversely affected (30 CFR 769.13 and ARM 26.4.1144).

In addition to the criteria discussed above which the Secretary must apply in order to reach a determination, the Congress has designated certain areas as unsuitable for surface coal mining. Those areas include all National Parks, all National Wildlife Refuges, and the Federal land within the boundaries of most National Forests, including, specifically, Custer National Forest (SMCRA, Section 522(e)(2)(B)). However, Congress did not intend to prohibit mining on privately owned inholdings in National Forests (H. R. Report No. 95-218, 95th Congress, 1st Sess. 94 (1977)). Accordingly, the following described fee lands located within the boundary of Custer National Forest (privately owned coal and surface) will be evaluated and included in the decision on this petition:

T. 3 S., R. 45 E., MPM: sec. 1 (all), sec. 11 (all), sec. 12 (N½SW¼, SE¼NW¼), sec. 13 (all), sec. 15 (all), and sec. 23 (all); and

T. 4 S., R. 45 E., MPM: sec. 29 (NE¼).

The Coal Creek mine (T. 3 S., R. 45 E., sec. 3), which is also in the Custer National Forest, is exempt (grandfathered) from this petition because it was operating under an approved permit prior to the filing of this petition.

Section 523(c) of P.L. 95-87 provides that the Secretary of the Interior may not delegate his duty to designate certain Federal lands as unsuitable for surface coal mining. Accordingly, in the event that the Director, OSM, and the Commissioner, Montana DSL, disagree as to an unsuitability decision on the entire Tongue River petition area, the former would make the final decision for Federal lands within the area and the latter would make the final decision for State and private lands within the area.

Legislative Mandate: Bureau of Land Management

The Federal Land Policy and Management Act (FLPMA) of 1976, P.L. 94-579, 90 Stat. 2743, 43 U.S.C. 1701 et seq., directs the Bureau of Land Management to use comprehensive land use planning. The land use planning requirement on Federal lands is also contained in the Federal Coal Leasing Amendments Act of 1976 (30 U.S.C., Section 201(a)(3)(A)(i)). Any proposed leasing of Federal coal deposits must be compatible with an adequate comprehensive land use planning decision.

Federal lands in the Ashland and Otter Creek coal fields were included in the Decker-Birney and Coalwood land use plans completed in 1974 and 1975. These areas were recommended for leasing in these land use plans. These same lands were subjected to the Federal Lands Review process in 1979 which included application of (1) BLM's unsuitability criteria for mining as per 43 CFR 3461, and (2) the surface-owner consultation provisions for SMCRA.

The remaining Federal lands in the petition area were also covered by land use plans completed in 1974 and 1975. Due to the lack of coal data and multiple-use tradeoffs at that time, they were not recommended for coal leasing at that time. These lands will be included under the newly required Resource Management Plan (RMP), scheduled for completion in 1984. The RMP will include the identification of high and moderate potential coal resources, the application of the Federal Lands Review process and multiple-use tradeoffs and alternatives. The issues raised in the petition will be among those analyzed in the RMP. (See also appendix C.)

CHAPTER II.

DESCRIPTION OF THE PETITION AREA

The Tongue River petition area has been described in the following documents: "Northern Powder River Basin Coal, Montana," volume 1, regional analysis (U.S. Geological Survey and Montana Department of State Lands, 1979), the Land Planning and Classification report on the Public Domain Lands in the Tongue River area, Montana, Wyoming (U.S. Bureau of Land Management, 1967), and the Powder River Coal Region draft EIS (U.S. Bureau of Land Management, 1981). The following section contains only information necessary for responding to the petitioners' allegations and for evaluating the environmental impacts of the various alternatives. A more complete description of the petition area can be found in the above documents.

Location and Topography

The petition area includes about 304 square miles in southeastern Montana and is partially bounded by the Northern Cheyenne Indian Reservation and the Tongue River on the west and by Custer National Forest on the south and east (fig. I-1). The petition area includes parts of Rosebud and Powder River Counties, and the relatively small communities of Birney, Ashland, and Brandenberg; it extends about 72 miles along the 186 river-miles of the Tongue River within Montana.

The petition area varies from rolling terrain to eroded bluffs with most of the arable land limited to the narrow stream valleys, plateaus, and some gently rolling uplands. The Tongue River and its major tributaries flow in valleys that are characterized by narrow flood plains which merge into rough, broken, eroded lands often flattening into plateaus. The steeper parts of the area are covered with open stands of ponderosa pine. Most of the more densely forested land lies outside the petition area, within the Custer National Forest and the Northern Cheyenne Indian Reservation. Lands along the larger drainages are commonly irrigated. Smaller tributaries are ephemeral and have channels ranging from broad and grassy to steeply walled and susceptible to erosion.

Geology

The petition area is underlain by the Fort Union Formation. This essentially flat-lying formation has a total thickness of about 2,000 feet and is chiefly massive light-yellowish-gray sandstone with interbedded shale and extensive coal beds. Over large areas these coals have burned along the outcrops, forming beds of red and brown clinker. (See chapter III for a discussion of clinker.) The Fort Union Formation was deposited some 50 to 60 million years ago in a vast shallow fresh-water lake which extended from east-central Wyoming to northern Montana and from central Montana eastward to the middle of North Dakota. Broad swamps and lowlands supporting luxuriant forests existed for long periods, forming thick and extensive coal beds. The Fort Union Formation contains an abundant fossil flora of some 400 species of plants, resembling those of modern times, and fossil fauna, including fish, fresh-water molluscs, and reptiles.

Large reserves of low-sulfur subbituminous coal occur in the Fort Union Formation; heat values of the coal range from 8,000 to 9,000 Btu/lb. Many townships contain five to eight coal beds with average thicknesses of more than 6 feet. Beds 20 to 25 feet thick occur over many square miles, typically lying horizontally near or at the surface.

The Sawyer coal bed, the uppermost bed of concern, is commonly either eroded or burned out within the petition area. Below this is the Knobloch seam which reaches a thickness of 75 feet in the Ashland area. The Wall and Brewster-Arnold beds lie south of Ashland; these beds are usually burned at the outcrop and, although they contain some recoverable resources, are generally too deep for economic recovery at this time. Wegemann (1910, p. 111) commented (in regard to these seams) that "coal is so plentiful almost every ranch has its own bank" and that "until a railroad runs up the Tongue River valley the demand for coal must be but local." Chapter III contains a detailed report on the coal resources of the petition area.

Hydrology

The surface-water system, the shallow ground-water system (to as much as 500 feet deep), and the interrelationship between the two are of principal interest in understanding and responding to the allegations in the Tongue River petition.

Surface water.--Surface water is used for irrigation and stock watering within the petition area. Typically, the water is impounded, diverted, or both. Part of the water used for irrigation returns to the surface-water system. Woessner and others (1980, p. 158) reported that approximately 26,700 acres were irrigated in the Tongue River Basin and its tributaries in Montana. (See also Lee and others, 1981.)

The petition area is wholly within the Tongue River drainage and includes about 304 square miles, or approximately 7 percent, of the approximately 4,100-square-mile drainage area. The Tongue River originates in the Big Horn Mountains in Wyoming, southwest of the petition area, and flows 265 miles to Miles City, Montana, where it joins the Yellowstone River. Major tributaries to the Tongue River rise from the low buttes to the southeast and northwest and flow through the petition area. Only Otter Creek and Hanging Woman Creek substantially affect flow in the Tongue River (table II-1). The delineation of recoverable coal (chapter IV) shows that no mining would occur in the Hanging Woman Creek drainage within the petition area.

The Tongue River, with an average annual flow of 330,000 acre-feet, has an average unappropriated and unused discharge of 241,000 acre-feet, of which 144,700 acre-feet has been allocated to Montana. The flow in Montana is largely controlled by the Tongue River Reservoir, upstream (south) from the petition area. The slow release of the stored, and generally better quality, spring runoff from the reservoir moderates the water quality downstream. Water quality of the Tongue River within the petition area might best be characterized by data from the station located at Brandenberg Bridge north of Ashland, where Knapton and Ferreira (1980) reported a mean total dissolved solids (TDS) value of 497 milligrams per liter (mg/L) and a sodium adsorption ratio (SAR)* of 4.5, neither of which is significant to plant growth (table II-2).

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*SAR is a measure of potential adverse effects on the physical properties of soils (a higher SAR is more adverse).

Table II-1.--Tributaries to Tongue River in the petition area

Tributary	Drainage area (mi^2)	Average annual discharge (cfs)	Reference
Hanging Woman Creek, 3.3 miles from nouth	470	6.45	([1])
Cook Creek, 0.1 mile from mouth	64.3	1.26	([4])
O'Dell Creek	46.3	---	([3])
Logging Creek, just upstream from mouth	38	0.73	([4])
Otter Creek, 2.5 miles from mouth	702	8.71	([1])
Beaver Creek, 0.8 mile from mouth	92.3	[5] 0.58 to 42.3	([2])

[1] U.S. Geological Survey, Water Resources Division, Water Resources Data for Montana, 1979.

[2] Knapton and Ferreira, 1980.

[3] Montco permit application, 1980d.

[4] Woessner and others, 1980.

[5] Due to the short period of record, the numbers present the range of flow measured.

Table II-2.--Levels of dissolved constituents in water which may affect water use[1]

(Source: Knapton and McKinley, 1977, and Knapton and Ferreira, 1980)

Parameter	Recommended limit[2]	Comments on use
Chloride	250 mg/L	Drinking water, secondary standard.[3]
Fluoride	2.2 mg/L	Maximum recommended for human consumption.
Iron	300 µg/L	Drinking water, secondary standard.
Lead	50 µg/L 100 µg/L	Drinking water, primary standard. Deleterious to fish above this level.
Manganese	50 µg/L 500 µg/L	Drinking water, secondary standard. Toxicity to selected plants.
Phosphorus	0.1 mg/L	Maximum concentration for protection of aquatic life.
Sulfate	250 mg/L 1,000 mg/L	Drinking water, secondary standard. Threshold for cattle consumption.
TDS	500 mg/L	Drinking water, secondary standard.
	less than 170 mg/L	Low salinity hazard for irrigation.
	170-500 mg/L	Medium salinity hazard.
	500-1,500 mg/L	High salinity hazard.
	greater than 1,500 mg/L	Very high salinity hazard.
Alkali hazard, as measured by SAR	0-10 10-18 18-26 greater than 26	Low hazard for irrigation. Medium hazard. High hazard. Very high hazard.

[1]It should be noted that waters used in the petition area can naturally exceed the standards, but are used out of necessity.

[2]mg/L = milligrams per liter; µg/L = micrograms per liter.

[3]Primary standards apply to health effects, whereas secondary standards apply to esthetic values (color, taste, etc.).

Surface-water quality in the petition area varies with the seasons and with location (Knapton and Ferreira, 1980), owing to the changing contributions of ground-water inflow, runoff, and discharge from the reservoir. Water quality data for selected points on the Tongue River and its tributaries (fig. II-1) are presented in Knapton and Ferreira (1980). These data (summarized in table II-3), when compared with water quality values of concern for various water uses (table II-2), show that the Tongue River is a source of good untreated drinking water.

Data from Knapton and Ferreira (1980) and Lee and others (1981) indicate that TDS levels in Hanging Woman and Otter Creeks are much higher than those in the Tongue River. This is primarily due to the higher TDS levels of the ground-water contribution to streamflow. Higher TDS levels are typical of the smaller tributaries in the petition area (table II-3). Historically, these streams have been heavily used for irrigation, thus contributing to the higher TDS levels. These high TDS levels are rapidly diluted by the Tongue River.

Ground water.--The Northern Great Plains Resource Program (U.S. Department of Commerce, 1974) reported that in the area of the Tongue River, from the reservoir to Birney, ground water is the primary source of water for domestic and municipal supplies and is an important source for livestock. The Resource Program also noted that "without water from wells or springs, much of the upland range could not be utilized by domestic animals" (U.S. Department of Commerce, 1974, p. 51). Numerous ranchers and farmers depend on ground water for domestic and stock use.

The ground-water system in the petition area can be considered to consist of three major parts. These are:

(1) The unconsolidated alluvium, principally the alluvial deposits that occur along the Tongue River;

(2) The Tongue River Member of the Fort Union Formation, occurring throughout the petition area; and

(3) The deeper strata of the Fort Union Formation, the Hells Creek Formation, and the Fox Hills Sandstone.

The general water-bearing characteristics of strata in the petition area are shown in table II-4. Water quality in wells drilled in the Tongue River alluvium in the petition area is characterized by 32 analyses, the results of which are shown in table II-5. These wells, most of which are in the southern three-fourths of the petition area, occur principally along the Tongue River and Otter Creek. The alluvium receives water from the adjacent Tongue River Member of the Fort Union Formation, from the river, and from precipitation. For this analysis, the transmissivity of the alluvium was assumed to be 5,000 ft^2/day. Woessner and others (1980, p. 110) reported yields of 10 to 700 gallons per minute (gpm) for alluvial wells in the area. The water is characterized by sodium, calcium, magnesium, bicarbonates, and sulfates, with TDS ranging from 612 to 3,500 mg/L. For the petition area, specific conductance (SC)** and SAR data (Montco, 1980d; Woessner and others, 1980; Hopkins, 1973) have been used to derive a mean SC of 1,490 micromhos per centimeter (μmhos/cm) and an approximate average SAR of 5.4 (with a median of 2.6). As can be seen in appendix A, the SC and SAR values vary little and show no trends.

** SC is a measure of salinity.

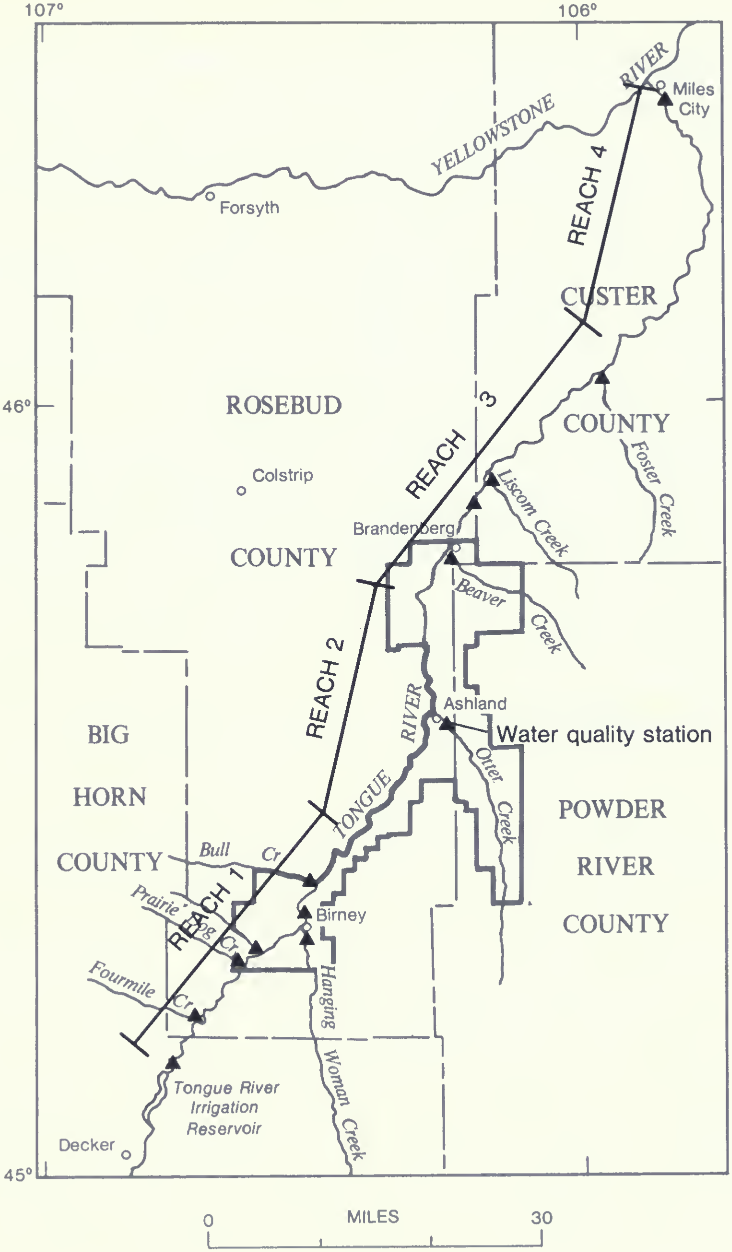

Figure II-1.--Location of selected water quality stations and seepage run reaches.

Table II-3.--Water-quality appraisal chart for selected stations

(Data are from Knapton and Ferraira, 1980. Lower numeral, number of times sampled; upper numeral, number of times sample was greater or less than stated value. Abbreviations: SAR = sodium adsorption ratio; Na = sodium; BOD = biochemical oxygen demand; NH_4 = ammonia; P = phosphorus; Fe = iron; Mn = manganese)

Station No. (fig. II-1)	Suspended sediment <20 mg/L	Suspended sediment <100 mg/L	Suspended sediment >5,000 mg/L	Temperature >25°C	Dissolved solids <500 mg/L	Dissolved solids <1,000 mg/L	Dissolved solids >4,500 mg/L	SAR >10	Percent Na >50	Dissolved sulfate <250 mg/L	Dissolved sulfate >1,000 mg/L	Dissolved oxygen <80 percent	Dissolved oxygen >110 percent	ph >8.5	BOD >8	Total NH_4 >0.07 mg/L	Total P >0.1 mg/L	Dissolved Fe >300 mg/L	Dissolved Mn >50 mg/L	Station name
15	24	33	0	0	17	34	0	0	0	33	0	0	2	4	0	13	0	1	2	Tongue River at Tongue River
	33	33	33	35	34	34	34	35	34	34	34	34	34	35	33	35	35	35	12	Dam, south of petition area
16	0	1	0	0	2	2	0	0	0	2	0	0	0	0	1	0	2	0	0	Fourmile Creek near Birney,
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	south of the petition area
17	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	Prairie Dog Creek near
	4	4	4	3	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	Birney, within petition area
18	0	2	0	0	1	2	0	0	0	2	0	0	0	0	1	0	1	0	0	Bull Creek near Birney,
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	within the petition area
21	4	34	0	0	3	4	0	0	3	3	12	10	2	0	2	11	9	3	6	Hanging Woman Creek near
	47	47	47	48	46	46	46	46	46	47	47	47	47	47	46	47	46	46	11	Birney, within petition area
22	19	34	0	0	24	45	0	0	0	37	0	1	---	7	0	4	7	0	2	Tongue River below Hanging Woman Creek, within petition
	41	41	41	48	44	44	44	45	45	46	46	48	48	48	36	45	45	47	18	area
23	14	31	0	0	1	3	0	0	0	1	0	3	2	2	0	1	3	0	5	Cook Creek near Birney,
	34	34	34	34	33	33	33	33	33	34	34	34	34	34	34	34	34	33	7	within petition area
29	3	33	0	1	3	4	0	0	11	3	33	10	1	5	2	18	8	2	3	Otter Creek at Ashland,
	45	45	45	46	45	45	45	46	46	46	46	45	45	45	46	45	46	46	10	within petition area
30	4	9	0	0	2	3	0	0	0	2	6	4	0	0	2	2	3	0	0	Beaver Creek near Ashland,
	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	0	within petition area
31	4	9	0	0	17	4	0	0	0	26	0	4	1	1	1	3	9	0	0	Tongue River below Brandenberg Bridge, within
	13	13	13	47	44	44	44	45	45	44	44	46	46	45	44	44	45	45	12	petition area
32	0	2	0	0	3	3	0	0	1	3	0	0	0	0	1	1	3	0	0	Liscom Creek near Ashland,
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	0	north of petition area
33	3	6	0	0	3	4	1	7	13	3	7	4	0	0	2	6	7	1	1	Foster Creek near Volborg,
	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	2	north of petition area
38	3	19	0	1	15	50	0	0	1	28	0	1	2	3	0	1	18	0	0	Tongue River at Miles City,
	36	36	36	73	50	50	50	50	50	50	50	73	73	73	7	14	50	18	18	north of petition area

Table II-4.--Generalized section of geologic units[1]

Series	Geologic unit	Thickness (feet)	General water-bearing characteristics
			Quaternary system
Holocene and Pleistocene	Alluvium	0 - 100	May yield as much as 500 gpm to irrigation wells in the Tongue and Powder River valleys; probably could yield up to 100 gpm to wells along Otter and Hanging Woman Creeks. Yields less than 50 gpm to stock and domestic wells in rest of basin. Water normally contains about 1,500 mg/L dissolved solids. Calcium, magnesium, and sulfate are the major constituents.
			Tertiary system
Paleocene/Fort Union Formation	Tongue River Member	0 - 2,500	Contains the major aquifers in much of the area; reportedly yields up to 60 gpm to wells and springs. The aquifers are under artesian conditions except near their outcrops. Many wells along the Tongue and Powder Rivers, and principal tributaries, flow. Water contains as much as 7,770 mg/L dissolved solids. Major constituents may include calcium, magnesium, sodium, bicarbonate, and sulfate. Water ranges from very hard to moderately soft; hardness decreases with depth. Locally contains small amounts of dissolved nitrogen and methane.
	Lebo Shale Member	0 - 600	Not known to yield water in the Decker-Birney area but yields small supplies in other parts of the basin.
	Tullock Member	0 - 800	Yields as much as 35 gpm to flowing wells in the Decker-Birney area where wells are as much as 1,200 feet deep. May yield as much as 500 gpm in the southern part of the basin, where the formation is from 500 to 1,500 feet deep. Water moderately soft, contains from 700 to over 2,000 mg/L dissolved solids.

[1]See end of table for explanation of footnote.

Table II-4.--Generalized section of geologic units[1]--Continued

Series	Geologic unit	Thickness (feet)	General water-bearing characteristics
			Cretaceous system
Upper Cretaceous	Upper Hell Creek Formation	0 - 850	Not tapped by wells in the Decker-Birney, but in other areas of Montana yields as much as 50 gpm to flowing wells and to springs. Yields as much as 500 gpm are believed possible in the south-central parts of the basin in Wyoming. Depth to the top of the formation is at least 1,000 feet in the Decker-Birney area and about 2,000 near Gillette. Water is probably similar in type and total dissolved solids content to that in the Tullock Member of the Fort Union Formation.
	Lower Hell Creek Formation and Upper Fox Hills Sandstone	0 - 280	Yields as much as 40 gpm to small-diameter flowing wells and as much as 20 gpm to small-diameter pumped wells. Yields as much as 200 gpm to industrial wells. In Decker-Birney area, water is under artesian pressure. Depths to top of the aquifer range from 1,300 to 4,000 feet in the Decker-Birney area. In the central part of the Powder River Basin in Wyoming, depths to the top are about 6,000 feet. Water is likely to be a sodium bicarbonate type; may contain as much 1,500 mg/L dissolved solids. Fluoride concentrations exceeding 2 mg/L commonly occur in water from deep wells in Wyoming.
	Bearpaw Shale	0 - 800	A confining bed; generally does not yield water to wells in the Powder River Basin of Montana and Wyoming.

[1]Modified from Lewis and Roberts (1978) and U.S. Department of Commerce (1974).

Table II-5.--Summary of ground-water quality by strata

(Source: U.S. Geological Survey, Water Resources Division, printout regarding wells in the vicinity of the petition area, 1981)

Water source	Number of wells	Quality	Concentration (mg/L) TDS	SAR	Fluoride	Chloride
Within the petition area						
Alluvium (Tongue River and tributaries)	19	Minimum	705	3.2	0.4	4.2
		Maximum	2,751	7.0	1.1	17
Tongue River Member	74	Minimun	508	0.6	0.1	0.1
		Maximum	5,261	113	13	150
Lebo Shale	1	---	1,451	45.9	2.9	65
Tullock Member	12	Minimum	618	14	0.8	0.9
		Maximum	2,380	109	7.0	180
Within and adjacent to the petition area						
Alluvium (Tongue River and tributaries)	37	Minimum	705	1.5	0.2	4.2
		Maximum	2,751	7.6	1.1	17
Tongue River Member	181	Minimun	162	0.6	0.1	0.1
		Maximum	5,720	113	13	150
Lebo Shale	1	---	1,451	45.9	2.9	65
Tullock Member	12	Minimum	618	14	0.8	0.9
		Maximum	2,380	109	7.0	180

Water in the near-surface aquifers is commonly perched over shale and other relatively impermeable materials that retard the downward movement of water, thereby creating local zones of saturation above the regional water table. Ground water flows in the direction of the hydraulic gradient, which generally conforms to the surface topography. Where the impermeable beds are exposed by erosion, ground water is commonly discharged as seeps and springs along bedding planes, joints, and fractures. Discharge of ground water is by upward leakage to the river valleys of the area. Ground water under artesian pressure is common in the river bottoms, and many of the deep wells drilled on the flood plain flow at the land surface.

The aquifers most commonly used in the area are the sandstone and coal beds in the Tongue River Member of the Fort Union Formation. The sandstone beds are lenticular and generally do not extend for more than a few miles, nor do they yield more than a few gallons of water per minute to wells. Coal aquifers are more widespread, but their ability to yield water varies from place to place. Data provided by the U.S. Geological Survey (computer printout, 1981) showed a large number of wells completed in the Tongue River Member within or immediately adjacent to the petition area with a wide range of water quality and quantity characteristics (appendix B). Most of the coal beds that are saturated and lie within a few hundred feet of the surface may yield as much as several tens of gallons per minute to wells. Aquifer test data and hydrologic gradient yield measurement data from Woessner and others (1980, p. 225) and Montco (1980d) were used to derive an inflow rate through the coal and overburden toward the Tongue River of 5,000 ft^3/day per river-mile (per side of the river) for this analysis. A transmissivity of 110 ft^2/day for the coal and overburden zone was estimated using data from the Montco mine permit application (1980d). Woessner and others (1980, p. 128) used a transmissivity of 121 ft^2/day for this zone.

Specific conductance and SAR values for ground water in the coal bed and interburden aquifers were averaged from Woessner and others (1980, p. 434-526) and Montco (1980d, table Bc11-1). Average SC was 3,300 umhos/cm; the average SAR was 36.5.

Most of the shallow ground water in southeastern Montana from the Fort Union Formation is of the sulfate type and contains several thousand milligrams per liter of total dissolved solids (tables II-5 and II-6). In some areas (U.S. Geological Survey and Montana Department of State Lands, 1979, p. II-19), ground water contains lead concentrations of almost twice the recommended maximum Public Health Service standard of 0.05 mg/L (U.S. Department of Health, Education, and Welfare, 1962). The source of this lead is unknown.

Water from deep wells in southeastern Montana contains very little magnesium and calcium, but has a high sodium content, which makes it undesirable for irrigation. Water from these wells is typically lower in total dissolved solids than that from shallow wells (table II-6). The water is of the bicarbonate type and does not contain excessive lead, but its fluoride concentration (table II-5) commonly exceeds the maximum level of 2.2 mg/L recommended for human consumption. The highest measured concentration of fluoride is 7 mg/L (U.S. Geological Survey and Montana Department of State Lands, 1979, p. II-20).

Table II-6.--Total dissolved solids concentrations for wells of known use within or adjacent to the petition area

(Source: U.S. Geological Survey, Water Resources Division, printout regarding wells in the vicinity of the petition area, 1981)

Formation	Known well use	Number of wells	Mean TDS ± standard deviation
		Within the petition area	
Alluvium	Domestic	3	1,175 ± 407
	Stock	3	1,953 ± 547
Tongue River	Domestic	12	1,267 ± 807
	Stock	35	1,467 ± 676
Lebo	Domestic	1	1,451
	Stock	0	---
Tullock	Domestic	0	---
	Stock	9	1,398 ± 483
		Within and adjacent to the petition area	
Alluvium	Domestic and stock	20	1,400 ± 639
Tongue River	Domestic and stock	115	1,687 ± 1,192
Lebo	Domestic and stock	1	---
Tullock	Domestic and stock	11	1,397 ± 664

Permeable beds are less common in the Lebo Shale Member than in the overlying Tongue River Member or the underlying Tulloch Member of the Fort Union Formation. The Lebo Shale is not considered to be an important aquifer in the petition area (U.S. Department of Commerce, 1974), although one well in the Lebo Shale occurs in the petition area (table II-6).

The Tullock Member yields as much as 35 gpm to flowing wells in the Birney-Decker area, and the water contains from 700 to over 2,000 mg/L dissolved solids (table II-5). The Tullock Member is considered to be the shallowest continuous aquifer to underlie the entire petition area. In addition, the less permeable, overlying Lebo Shale should prevent any mining-related deterioration in ground-water quality from moving down into the lower aquifers (Woessner and others, 1980).

The lower part of the Hell Creek Formation (Upper Cretaceous age) is comprised of permeable sandstones, which, along with the underlying Fox Hills Sandstone, forms a continuous aquifer believed to underlie essentially the entire area (U.S. Geological Survey and Montana Department of State Lands, 1979, p. II-19). In some areas, this aquifer yields industrial supplies of 100 to 200 gpm. Although this aquifer has not been tested in the western part of the Powder River Basin, it is probably the next shallowest source of consistent supplies. Broadus obtains its water supply (100 acre-feet annually) from this aquifer. Water from the Hell Creek-Fox Hills aquifer usually is of the sodium bicarbonate type; it is extremely soft and is suitable for drinking, but its excessive sodium content makes it generally unsuitable for irrigation (U.S. Department of Commerce, 1974, table V-A-4).

The formations that underlie the Hell Creek-Fox Hills aquifer and overlie the Madison Limestone are generally of poor permeability and yield poor-quality water (U.S. Geological Survey and Montana Department of State Lands, 1979, p. II-19). The Madison Limestone, a large-yield aquifer, is considered to be too deep to be a viable alternate source of water in the event other domestic or agricultural sources are disturbed by mining.

Climate

The Tongue River petition area is a dissected plain ranging in elevation from about 2,768 feet to 4,162 feet above mean sea level. The average annual precipitation is from 13 to 15 inches, varying with the terrain. Birney, with an average annual precipitation of 13.7 inches, is typical of the region.

Much of the spring precipitation occurs as thunderstorms in May and June and is often accompanied by high winds and sometimes hail. Hot dry periods with high winds are normal throughout the summer season. Winters are cold, high winds sweep the region, and blizzards are common. Most years, snowfall in the plains blows away, collecting as drifts in draws and low places and leaving fields and roads bare.

Average growing seasons vary from about 125 days at Brandenberg Post Office to 108 days at Birney; unseasonable (early) frosts are common.

Air Quality

Air quality within the petition area is generally good. The petition area has some air-quality problems with total suspended particulates (TSP) and fugitive dust; however, concentrations of gaseous pollutants are well below State and Federal standards (U.S. Geological Survey and Montana Department of State Lands, 1979).

Soils

The soils of the petition area are highly variable in terms of their depth, texture, color, profile morphology, and coarse fragment content. These diverse characteristics reflect the variability of topography, parent materials, and vegetation in the petition area.

Lowlands of the petition area are characterized by alluvial soils of the Tongue River and Otter Creek flood plains and their major tributaries and the soils of associated alluvial fans. These soils are usually deep and occur on relatively gentle slopes. Textures range from gravelly and sandy loams to clays, and the soils are poorly to well drained. The soils are variably affected by sodium and soluble salts, resulting in the variation of SAR levels. Carbonates are common in the C horizons.

Uplands of the petition area consist primarily of residual, colluvial, or locally derived alluvial soils. A significant portion of these soils are shallow (less than 20 inches deep), are poorly developed, may have abundant coarse fragments, and occur on moderate to very steep slopes (15 to 70 percent). On the benches and plateaus, deeper soils and gentler slopes are common. Upland soils are principally derived from shales, siltstones, and clinker; are typically calcareous in the C horizons; and contain varying quantities of sodium and soluble salts. This last characteristic has resulted in a wide range of SAR levels. Drainage is generally good to excessive in the upland soils.

More specific information on soil characteristics in the petition area is discussed in relation to the allegations regarding vegetation and soils in chapter IV.

Vegetation

Topography in the petition area, consisting of intricately dissected benches and ridges, clinker outcrops, badlands, colluvial slopes, alluvial fans, relatively flat alluvial valleys, and ephemeral, intermittent, and perennial stream bottoms, supports various vegetative communities. Bench tops and ridgetops are predominantly grasslands (wheatgrasses, needlegrasses, etc.) frequently dominated by ponderosa pine and sage (big sage and false tarragon sagewort) with interspersions of other shrubs and forbs.

The north-facing slopes of the breaks are dominated by ponderosa pine and/or juniper, whereas the more south-facing slopes are dominated by skunkbush sumac, curl-leaf mountain-mahogany, greasewood, and various other shrubs; grasses including bluebunch wheatgrass, little bluestem, and prairie sandreed; and mixed forbs.

The badlands common throughout the area are occupied by xeric (dry) communities (including saltbush, bluebunch wheatgrass, inland saltgrass, eriogonum, rubber rabbitbrush, and broom snakeweed) with relatively low vegetative cover.

Horizontally stratified sandstones, shales, and clinker slopes give rise to stratified bands of shrub communities. The lower slopes of the petition area are predominantly covered by shrub-dominated grasslands or by grasses, mixed forbs, and scattered shrubs. The bottomlands consist of agricultural lands, mostly hay meadows or small-grain fields, or grasslands and shrubby grasslands. Such native species as big sage, silver sage, fringed sage, greasewood, broom snakeweed, bluebunch and western wheatgrass, needlegrass, grama grass, sedge, annual brome grass, and prickly pear cactus are common in both of the above areas.

Some of the scrublands and grasslands contain relatively small inclusions of halophytic (salt-tolerant) communities. Typically dominant species in these communities are greasewood, saltbush, and sage.

The vegetation in the major drainages of the petition area are typical of southeastern Montana deciduous-tree and shrub-riparian communities. Cottonwood, green ash, box elder, willow, and rose are some of the more common species along these drainages.

Ephemeral and intermittent stream drainages are occupied by various combinations of such species as chokecherry, plum, snowberry, rose, buffaloberry, juniper, box elder, green ash, wheatgrass, bluegrass, and a variety of forbs.

Wildlife

Big game species in the petition area include mule deer, antelope, and a few white-tailed deer. Four species of game birds (sharptail and sage grouse, ringneck pheasant, and Hungarian partridge) and numerous nongame birds are found in the area. The area contains many active sharptail grouse dancing grounds. Raptor species in the area include eagles, hawks, falcons, and owls. There are some high-priority seasonal use areas within and adjacent to the petition area for big game, game birds, and raptors. (See Knapp, 1975, 1977; Martin, 1980.) Many medium-sized and small mammals are also in the petition area. (See also U.S. Geological Survey and Montana Department of State Lands, 1977.)

The region includes current and historic ranges of the whooping crane, peregrine falcon, black-footed ferret, and bald eagle. The U.S. Fish and Wildlife Service (FWS) has indicated that none of these species has critical habitat in the petition area (T. Blazecevich, Montana Department of State Lands, oral commun., 1981). Baseline studies to date have not revealed critical habitats of threatened and endangered species on any proposed or existing minesites.

The Tongue River below, and Hanging Woman Creek within, the petition area are considered high-priority fisheries. The Tongue River and Otter Creek within the petition area are considered to be substantial fisheries by the Montana Department of Fish, Wildlife, and Parks. Species found include pike, bass, sauger, other gamefish, and carp (U.S. Geological Survey and Montana Department of State Lands, 1977).

Social, Economic, and Community Services Background

Detailed information on social and economic conditions within the region, including the petition area, and the level of community services can be found in previous coal mine impact statements done for the area, as well as in the regional analysis: "Northern Powder River Basin Coal, Montana" (U.S. Geological Survey and Montana Department of State Lands, 1979); the draft Ashland plan (U.S. Forest Service, 1978); all of the Bureau of Land Management's analyses prepared for the 1982 coal lease sale for the petition area (U.S. Bureau of Land Management, 1981); and in the comprehensive plans for Powder River and Rosebud Counties (Powder River County Planning Board, 1981; Rosebud County Planning Board, 1979, 1980).

Ranching dominates the social and economic fabric of the Tongue River petition area. This rural, largely undeveloped area has a sparse population. Rosebud and Powder River Counties (with a population of 9,899 and 2,520, respectively) have experienced a 64.1 percent increase and an 11.9 percent decrease in population, respectively, for the period from 1970 through 1980 (U.S. Department of Commerce, 1980; U.S. Geological Survey and Montana Department of State Lands, 1979).

Recent area growth has come mainly from coal exploration. Many ranch-owners have leased their fee minerals to coal companies, while others have been opposed to mining. Should new mining operations be permitted, the subsequent population growth would be expected to occur in the vicinities of Ashland and Colstrip. In general, existing services in Ashland are insufficient to support any large-scale population growth, whereas services in Colstrip might be sufficient to support the anticipated growth.

Land Use

Climate, soils, and terrain determine the plant species native to the area, as well as their distribution and production. These factors also limit choice and production of domestic crops. Under irrigation, alfalfa, sugar beets, or other hardy plants are the usual crops in southeastern Montana (U.S. Bureau of Land Management, 1967, p. 4). Dry farming is usually confined to small grains, sorghums, or corn under a fallowing system that produces a crop in alternate years (U.S. Bureau of Land Management, 1967, p. 4). Farming, however, occupies but a small part (not over 5 to 7 percent) of the area.

Most of the study area is in native grassland and open ponderosa pine stands used for livestock, wildlife, timber, recreation, and watershed. The area's broken terrain is valuable in this severe climate, for the badlands, gullies, and coulees, typical of 75 percent of the region, give shelter in the winter to livestock and wildlife.

Recreation

Custer National Forest, adjacent to the petition area, is a focal point for grazing, wildlife, timber, and various types of recreation including hunting, hiking, driving, picnicking, etc. (U.S. Forest Service, 1978). Part of Custer National Forest (just east of the east-side Tongue River Road) is being managed as the Tongue River Breaks, for primitive recreation. Within the petition area, 1,484 acres of BLM lands adjoining the forest are being considered for wilderness designation (U.S. Bureau of Land Management, 1980). In addition, 8,732 acres along Zook Creek (south of the reservation) are being considered for such designation. Both the Breaks and the Zook Creek areas contain primarily high-overburden coal with little probability of recovery. A final decision on the wilderness designations must be made by 1990.

Transportation

Because population is sparse and the towns are widely separated, most people and consumer goods in the study area move by roadways. The road network is not well developed but is generally adequate for the existing population. U.S. Highway 212 and Federal Aid Secondary Highways 314, 332, 484, and 566 pass through the petition area.

The Interstate Commerce Commission is currently preparing an environmental impact statement on a proposed railroad route along the Tongue River, from Miles City to the proposed Montco minesite, with a spur extending up Otter Creek to the proposed BLM coal lease tracts. There is no rail transportation within or adjacent to the petition area at the present time.

Cultural Resources

The petition area is rich in cultural resources, judging from the historic and archeologic surveys completed in the area. These surveys indicate a site density of 4.3 to 8.7 sites per square mile. (See Montco, 1980a, b; U.S. Forest Service, 1978; U.S. Bureau of Land Management, 1981.)

CHAPTER III.

EVALUATION OF COAL RESOURCES AND SUPPLY AND DEMAND FOR COAL

This chapter represents the detailed statement of the coal geology, potential coal resources of the area, the demand for coal, and the impact of a designation of unsuitability on the economy and coal supply as required by Section 522(d) of SMCRA and 82-4-228, MCA, of SUMRA. The impact on the environment of a designation by alternative scenarios is discussed in chapter V.

A. COAL RESOURCES

The coal geology and coal resource discussion in this chapter is abstracted from the U.S. Geological Survey report of July 2, 1981 (1981c). Those portions of the report duplicating the general geology discussions in chapter II have been deleted. The coal resource data represent only those data available to the Montana Bureau of Mines and the Geological Survey at the time of preparation. New or additional coal resource data that would cause a significant change in this chapter and the substance of the final detailed statement are solicited in response to this draft. The purpose is to provide an adequate and appropriate statement for consideration in the decision for disposition of the petition to designate all or part of the area unsuitable for all or certain types of surface coal mining operations. Figure III-1 shows the known recoverable reserves in the petition area.

Stratigraphy

The area is underlain primarily by the Tongue River Member of the Fort Union Formation of Paleocene age. A lower member, the Lebo Shale, crops out in the northern part of the area along the Tongue River. The Tongue River Member is about 1,300 feet thick in the area and is characterized by an alternating sequence of pale-olive to yellowish-gray fine-grained sandstone, yellowish-gray claystone, interbedded claystone and sandstone, interbedded shale and claystone, thick coal beds, and carbonaceous shale.

The most striking characteristic of the Tongue River Member is the clinker, which was formed by the burning of thick coal beds and which covers large areas. This burning has caused fusion and baking of the strata overlying the coal bed which has produced a red to orange multicolored zone. In some places, these clinker zones are more than 200 feet thick.

Structure

The petition area lies along the axis of the Powder River structural basin. The strata are nearly flat lying, dipping ½$^{\circ}$ or less to the south. The dip is modified by local structures.

Ownership

The coal in the Tongue River petition area is under Federal, State, and private ownership. The Burlington Northern, Inc., is the largest private owner of

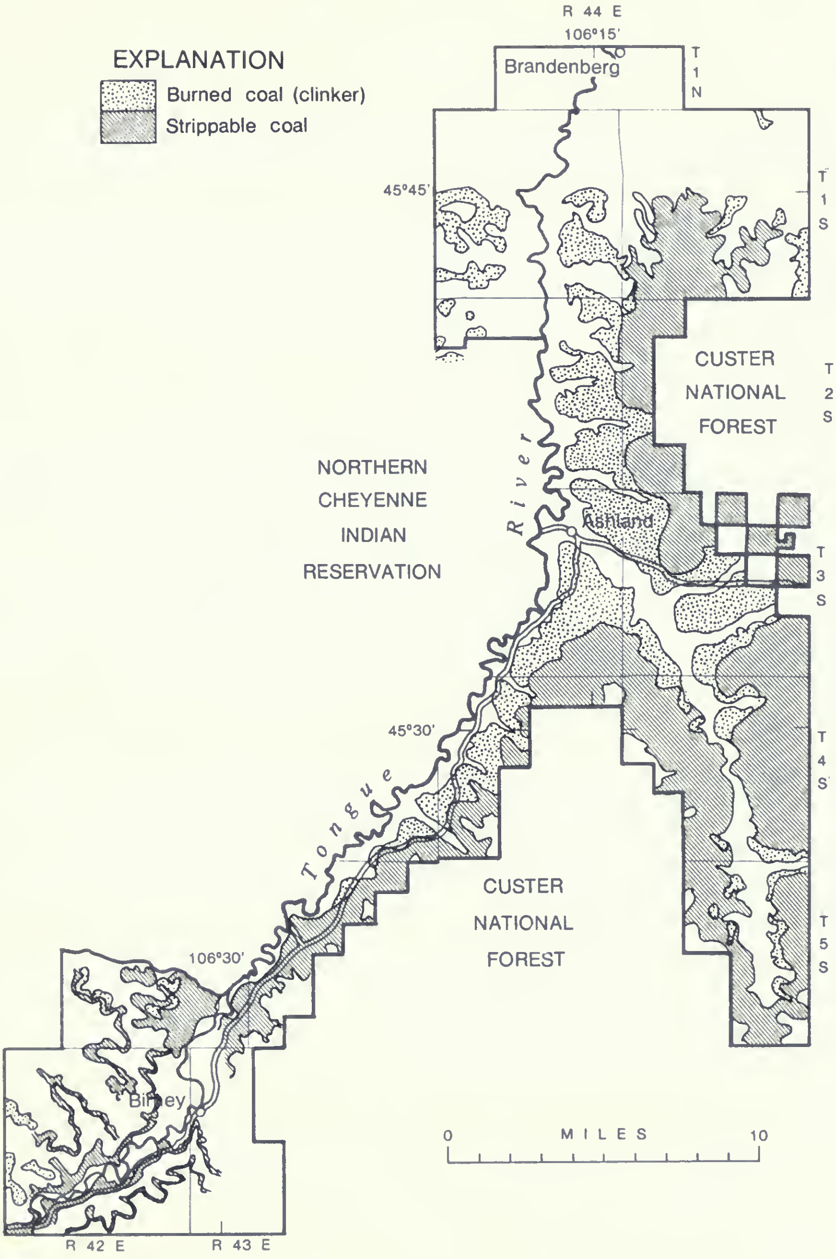

Figure III-1.--Known recoverable coal reserves within the petition area.

coal in the area, as this area lies within the original railroad land grant. Most of the Federal coal in the petition area lies under privately owned surface (table III-1).

Coal Geology

The coal beds in the petition area with mapped strippable reserves are the Knobloch, Sawyer, Brewster-Arnold, and Wall. Coal resources within the petition area are shown by bed in table III-1. Other lesser coal beds have been mapped in the area.

Beds Minable by Surface Methods

Knobloch coal bed.--The Knobloch coal bed ranges in thickness from 7 feet in the northern part of the petition area to 75 feet in the east-central part of the petition area.

The Knobloch coal bed crops out on the crests of the higher divides in the northern part of the petition area. Considerable coal has burned near the outcrop, and the resultant clinker, being resistant to erosion, caps many of the interstream divides. In the central part of the petition area, exposed sections of clinker are up to 150 feet thick. The red to orange clinker covers the sides of the principal valleys in the southern part of the petition area.

In the southern half of the petition area, the Knobloch coal bed splits into four coal beds. The lowest split of the Knobloch coal is the Nance coal bed. The next higher coal beds are the middle split of the Knobloch coal bed, the upper split of the Knobloch coal, and a thin local coal bed.

Coal quality analyses are given in table III-2 and indicate that the Knobloch coal is subbituminous C to subbituminous B in rank.

Sawyer coal bed.--The Sawyer coal bed occurs in the northern and southeastern part of the petition area. The bed is 4 to 16 feet thick and is 20 to 225 feet above the Knobloch coal bed.

The Sawyer coal bed splits into two coal beds in the southeastern part of the petition area. The lower split of the Sawyer coal bed was mapped by Bass (1932, plate 3) as the A coal bed and is from 1 to 6 feet thick. The upper Sawyer is 2 to 9 feet thick and is 20 to 40 feet above the lower Sawyer.

Coal quality analyses are given in table III-2 and indicate that the Sawyer coal is lignite A to subbituminous C in rank.

Brewster-Arnold coal bed.--The Brewster-Arnold coal bed crops out near the flood plain of the Tongue River and in the valleys of streams tributary to the river and ranges from 5 to 25 feet in thickness.

Coal quality analyses are given in table III-2 and indicate that the Brewster-Arnold coal bed ranks high in the range as subbituminous C.

Wall coal bed.--The Wall coal bed occurs in the southwestern part of the petition area. The bed ranges from 4 to 20 feet in thickness and thickens rapidly west of the petition area.

Table III-1.--Coal reserves in the Tongue River petition area for the Knobloch, Sawyer, Brewster-Arnold, and Wall coal beds (in millions of short tons)

Category	Federal	State	Private	Total
Knobloch coal bed				
Measured	232	93	187	512
Indicated	673	175	872	1,720
Inferred	443	31	635	1,109
Hypothetical	15	---	---	15
Total	1,363	299	1,694	3,356
Sawyer coal bed				
Measured	2	---	6	8
Indicated	2	less than 1	5	7
Inferred	less than 1	---	5	5
Total	4	less than 1	16	20
Brewster-Arnold coal bed				
Measured	15	---	2	17
Indicated	32	---	12	44
Inferred	15	3	1	19
Total	62	3	15	80
Wall coal bed				
Measured	4	---	---	4
Indicated	17	2	---	19
Inferred	3	1	1	5
Total	24	3	1	28

Table III-2.--Proximate analyses of coal from Knobloch, Sawyer, Brewster-Arnold, and Wall coal beds (as-received basis)

	Knobloch	Sawyer	Brewster-Arnold	Wall[1]
Moisture[2]	21.720 - 30.245	31.490 - 32.910	20.235 - 24.980	25.456
Volatile matter[2]	27.740 - 33.792	28.117 - 31.015	29.494 - 31.562	29.786
Fixed carbon[2]	32.069 - 43.386	32.014 - 35.601	40.607-43.121	38.548
Ash[2]	3.669 - 8.276	4.672 - 5.019	3.831 - 6.584	6.210
Sulfur[2]	0.095 - 0.594	0.297 - 0.634	0.241 - 0.701	0.427
Btu/lb	8,193 - 9,135	7,814 - 8,015	8,786 - 9,310	8,583
Number of samples	12	3	4	1

[1]The nearest coal quality data for the Wall coal bed is from a drill hole 4 miles west of the petition area in T. 6 S., R. 41 E., sec. 16, where the coal bed is 49 feet thick.

[2]Data are in percent.

The nearest coal quality data are from a drill hole 4 miles west of the petition area in T. 6 S., R. 41 E., sec. 16, where the coal bed is 49 feet thick. The coal quality analyses given in table III-2 indicate that the Wall coal is subbituminous C in rank.

Other coal beds.--Other beds of relative thinness and limited areal extent may contain reserves if mined in conjunction with one of the major beds.

Previous geologic work

The coal resources of the petition area have been described in Wegemann (1910), Bass (1924, 1932), Baker (1929), Warren (1959), Matson and others (1968), Ayler and others (1969), Matson, Blumer, and Wegelin (1973), Culbertson and Klett (1976), Mapel (1976), Mapel and others (1977, 1978), Malde and Boyles (1976), Mapel and Martin (1978), Colorado School of Mines (1979a, b, c, d, e, f), McKay (1976a, b, c), and McKay and others (1979). Compilations of this and other data have been prepared by members of the U.S. Geological Survey and Montana Bureau of Mines and Geology.

Data Accuracy and Reliability: Degree of Geologic Assurance

The four categories of geologic assurance used in this study are taken from U.S. Geological Survey Bulletin 1450-B. Measured reserves, for which estimates of coal quantity have been computed with an error of less than 20 percent, are within ¼ mile of points of information; the indicated reserves are contained in limits ¼ mile to 3/4 mile of points of information; the inferred reserves are contained in limits 3/4 mile to 3 miles of points of information; and, hypothetical reserves are limited to reserves farther than 3 miles from points of information.

Data Sources

Interpretation of the outcrops and burn lines are based on previous geologic reports all of which are listed in the bibliography attached to the July 2, 1981, report.

Assumptions Used in Reserve Calculations

When calculating reserves, a 6.5 to 1 stripping ratio (feet of overburden to feet of coal) was used with a 90-percent recovery factor. These assumptions were based on the conditions currently encountered in the active surface mines in the northern Powder River Basin. A factor of 1,770 tons of coal per acre-foot was also used in the calculations.

Reserves were not calculated for underground mining. (See Underground Mining section.)

Conclusions

Table III-3 shows the total coal reserves (3.484 billion tons) of the Knobloch, Sawyer, Brewster-Arnold, and Wall coal beds that could be precluded from mining by surface methods if the petition was granted in its entirety. Any decision to designate less than the entire petition area would affect a lesser amount of coal reserves.

Table III-3.--Total coal reserves that cannot be mined by surface methods if the petition is granted

Coal bed	Total (millions of short tons)
Knobloch	3,356
Sawyer	20
Brewster-Arnold	80
Wall	28
Total	3,484

Underground Mining

The technology to mine the Sawyer and several other thin beds exists. Indeed, much of the early mining in the Ashland area was underground (Bass, 1932). However, the following factors make underground mining uneconomical in this area today:

1. Market competition: If mined underground, the Sawyer coal would not be able to compete on the open market with the thicker strippable coals and higher grade underground coals of Montana and Wyoming. (See table III-4.) The high costs involved with underground mining add to the operators' marketing problems. Competition would be no better locally, inasmuch as the Ashland, Montana, area is currently served by a small surface coal mine.

2. Transportation: The Tongue River area is not presently serviced by rail lines. Underground mining would not produce the quantities of coal needed to develop and maintain the proposed Tongue River Railroad.

3. Subsidence: Many of these thin seams are under such low cover that they could not be developed underground without creating disturbance through subsidence (U.S. Department of the Interior, 1977, p. I-49; Stefanko, 1973, p. 13-4). The costs involved with mitigating subsidence would make underground mining even more prohibitive.

It is not technologically feasible to mine the Knobloch seam by underground methods at this time. The thickest coal being mined underground in the United States is 11 feet thick (Chironis, 1981). One company in Colorado is attempting to mine 28 feet of coal underground. However, that seam is 2,000 to 3,000 feet below the surface, allowing for minimum surface disturbance. The Knobloch, on the other hand, is 50 to 70 feet thick under less than 300 feet of cover. Even if a company decided it was feasible to mine the Knobloch by underground mining, only an average of 50 percent of the resource could be recovered (U.S. Department of the Interior, 1977, p. I-50).

Impact on Mining if Petition is Granted

There are no Federal coal leases within the petition area. At least half of the coal is privately owned and some of it has been leased. The State of Montana also owns coal in the area, about 80 percent of which has been leased. Nine companies have surface rights or coal leases in the area that would be affected if the petition is granted.

Montco currently has a mine permit application filed with the State of Montana. This planned 12-million-ton-per-year operation, which would be between Ashland and Birney, Montana, would not be able to proceed if the petition is granted. Likewise, the proposed Tongue River Railroad would be delayed or possibly not built if all surface mining were prohibited within the petition area. The impact to the proposed railroad is unclear if only part of the petition area were designated as unsuitable.

Table III-4.--Selected proximate analyses for coal producing regions, Montana and Wyoming

Parameter	Coal producing region/coal seam analyzed						
	Tongue River, Montana/ Sawyer[1]	Tongue River, Montana/ Knobloch[1]	Decker, Montana/ Dietz-1[2]	Colstrip, Montana/ Rosebud[1]	Roundup, Montana/ Mammoth[3]	Bear Creek, Montana/ No. 2[4]	Gillette, Wyoming/ Wyodak[5]
Thickness (feet)	10 - 15	50-70	50	25	7 - 9	8	75
Coal quality:							
Btu/lb (as received)	7,915	8,246	9,733	8,920	10,510	11,194	8,400
Sulfur (percent)	.35	.14	.42	.99	.60	1.44	.35
Ash (percent)	4.8	4.91	4.13	8.4	5.7	6.0	5.0
Moisture (percent)	32.25	30.00	23.63	23.10	16.90	10.03	28.00
Fixed carbon (percent)	33.8	37.1	39.0	40.1	44.6	46.7	34.0
Volatile matter (percent)	29.15	28.01	33.22	28.40	32.20	37.22	33.00
Mining method	Surface	Surface	Surface	Surface	Surface and underground	Under-ground	Surface

[1]Matson and others, 1973.
[2]Decker Coal Company, 1981.
[3]Divide Coal Mining Company, 1977.
[4]Woodruff, 1909.
[5]U.S. Geological Survey, 1980a.

Impact on Federal Leasing Program if Petition is Granted

There are five tracts of Federal coal within the peitition area that are being considered for leasing in the 1982 Powder River lease sale. Table III-5 shows pertinent information on these tracts.

These reserves figures have been included in the totals listed in the geology section of this report.

If the petition is granted, a maximum of 621 million tons of Federal coal will be removed from the 1982 Powder River Federal leasing target. In order to make up this deficit in 1982, the Department of the Interior might have to lease additional coal from the Gillette and Highlight Review areas in Wyoming. Since the current leasing target already includes coal from these areas, this additional leasing in 1982 could transfer impacts to that coal-producing region of Wyoming.

B. THE SUPPLY AND DEMAND FOR PETITION AREA COAL

National Supply and Demand for Coal

The demand for coal in the United States has increased steadily since the Arab Oil Embargo of 1973. As the price of oil and natural gas increases, greater substitution of coal for petroleum and petroleum-related products has been emphasized in order to meet national energy requirements. Coal is expected to remain a significant source of energy for years to come. Table III-6 displays Department of Energy (DOE) projections for national coal consumption by users through 1995.

However, actual future demand for coal will be affected by numerous factors, such as the development, availability, and price of alternative energy sources, the number of electric powerplants, the expansion of foreign markets, and other factors. By far the most important factor that will affect future demand for coal is OPEC's dominant role in the world petroleum market. The longer term consumption of coal, however, should not be affected by supply constraints in the future.

The production of coal in the United States has experienced a 40-percent increase since 1973, when 598 million tons were produced. National production in 1980 was 835 million tons and production is expected to increase continuously for the next two decades. The Department of Energy projects that coal production in the United States will surpass 1 billion tons by 1985 reaching nearly 1.9 billion tons by 1995.

Aside from the expected increase in coal production, there is still unused capacity in the coal industry. According to a DOE study, only 87.9 percent of the existing capacity in the coal industry is currently utilized. National coal consumption should not be limited by supply constraints over the foreseeable future.

Regional Supply and Demand for Coal

The production of coal in Montana has increased steadily since 1970. Coal production in Montana for 1979 was 32.4 million tons, or 4.1 percent of the total

Table III-5.--Estimated recoverable coal reserves of coal tracts within the petition area that are being considered for leasing in the 1982 Powder River lease sale

Tract	Recoverable Federal coal (million tons)	Recoverable State coal (million tons)	Recoverable private coal (million tons)
Ashland (Decker-Birney)[1]	108.9	55.8	202.5
Coal Creek[2]	60.0	11.0	93.0
Cook Mountain[2]	178.2	0.3	75.6
Northwest Otter Creek[1]	138.6	62.1	210.2
Southwest Otter Creek[1]	135.4	49.5	218.9
Total	**621.1**	**178.7**	**800.2**

[1]U.S. Geological Survey, 1980b.
[2]U.S. Geological Survey, 1981.

Table III-6.--Coal consumption by end-use sector

(Source: Department of Energy Annual Report to Congress, 1980)

	Consumption (millions of tons)			
	1978 (actual)	1985	1990	1995
Domestic consumption:				
Electric utility	481	720	882	1,167
Industrial	73	144	229	249
Emerging technology	---	12	140	266
Domestic coking	71	71	74	75
Total domestic consumption:	**625**	**947**	**1,325**	**1,757**
Net exports	38	85	108	143
Stockpiles:				
To stockpiles	7	0	9	0
From stockpiles	0	-1	0	-22
Total production:	**670**	**1,031**	**1,442**	**1,878**

national production of 781 million tons. Montana production of coal for 1980 was 30.0 million tons, or 3.6 percent of the total production nationwide of 835.4 million tons.

The Colorado Energy Research Institute (Sebesta, 1980) projects that the total demand for Montana coal between 1979 and 1986 should increase by 58 percent to approximately 51.4 million tons. By 1991, a 31-percent additional increase is expected, to a total demand of 67.2 million tons. Most coal production in Montana comes from the Powder River Basin and is used by electric utilities.

Supply and Demand for Petition Area Coal

An economic analysis was conducted comparing coal from the Tongue River petition area with other coals available to meet national coal demand in the year 1995. The analytical basis for the analysis is the U.S. Geological Survey's Coal Transportation Model (Bernknopf and Gordon, 1980). The model is a linear programing model which allocates coal produced nationally in mining districts by mining method and coal quality to consuming centers. The model selects an "optimal solution" that minimizes the total delivered cost of meeting given coal demands, expressed in Btu's per year, in 1995. There are 99 supply regions, 243 demand regions, and 4 modes of transportation (regulated rail, barge, unit train, and high-voltage transmission) in the model. Projected mining costs, transportation costs, and the costs of environmental protection measures associated with burning coal are considered. The model operates in constant 1978 dollars, thereby eliminating future inflationary effects from the results. An adjustment to the basic model was made for this study to reflect two separate scenarios for coal availability: (1) a limited leasing scenario reflecting current and proposed leasing, and (2) an unlimited leasing scenario to reflect an expanded Federal coal leasing program.

Basic information for the coal resources in the petition area were developed by the U. S. Geological Survey and the Montana Bureau of Mines and Geology. For purposes of this analysis, Tongue River coal is assumed to have a Btu content of 8,600 per pound, a sulfur content of 0.4 percent, and a 1995 price of $12 per ton at a minesite expressed in 1978 real dollars. The delivered price of coal from the petition area would also include transportation costs and a scrubbing cost to meet EPA emission standards. The coal transportation model computes transportation and scrubbing costs and adds them to the freight-on-board (FOB) mine price. The petition area is considered a separate supply region by the model for this analysis, and the coal is explicitly compared against all alternative methods of meeting 1995 national coal demand.

The coal transportation computer model demonstrates a high degree of substitutability between coal from the petition area and other coal resources in Montana and Wyoming under both the limited and the unlimited leasing scenarios. The model allocates nearly 45 million tons of coal from the petition area to Midwestern consuming regions under the limited leasing scenario (table III-7). The majority of coal (37.6 million tons) is shipped to the St. Cloud, Minnesota, consuming region at a delivered price of $34.86 per ton. The other major coal shipment is to Springfield, Missouri (6.9 million tons), with a delivered price of $28.91 per ton. It should be stressed that these shipments are indicators of possible coal shipments in 1995 and that actual shipment would probably vary to some extent.

Table III-7.--Coal shipment and costs from the Tongue River petition area under a limited leasing scenario, 1995[1]

(Values are in constant 1978 dollars)

Parameter	Consuming region[2] St. Cloud, Minnesota	Springfield, Missouri
Total coal shipped (millon tons)	$37.6	$6.9
Mine mouth cost (dollars/ton)	12	12
Transportation cost (dollars/ton)	13.16	7.21
Scrubbing cost (dollars/ton)[3]	9.70	9.70
Total delivered cost (dollars/ton)	34.86	28.91
Total delivered cost (dollars/MMBtu)	2.03	1.68

[1] Values in this table reflect new coal shipments from the petition area to the consuming region. Values in this table represent only a partial listing of the coal transportation model's results.

[2] Consuming regions are defined by the model and represent only a relative size and direction of the coal shipments. Actual shipments would probably vary.

[3] Scrubbing costs reflect EPA standards and are based on the PEDCO model prepared for EPA, "Cost Analysis of Lime-based Flue Gas Desulfurization Systems for New 500-MW Utility Boilers," January 1979.

The delivered price of coal from the petition area was adjusted upward to test the sensitivity of the shipments or the substitutibility of other coals under the limited leasing scenario. An increased delivered price of $2.36 per ton caused a production shift to the Powder River area of Wyoming for coal delivered to Springfield. At an increased price of $3.89 per ton in the petition area, coal supplied to St. Cloud shifts from the petition area to the Powder River Basin, Wyoming. Similar production shifts would also occur if the relative delivered price of coals in the region changed by similar amounts.

The model considered coal from the petition area slightly less competitive than other coals available under the unlimited leasing scenario. No coal was allocated from the petition area under the unlimited leasing scenario. Coal shipments to St. Cloud and Springfield under the unlimited leasing scenario came from north-central Wyoming and the Powder River area of Wyoming, respectively. However, the model demonstrates a high degree of sensitivity to the delivered price for coal from these supply regions. A decreased price of delivered coal from the petition area of just over $2 per ton shifts coal production to the petition area at a level of just under 45 million tons. Similar production shifts would occur if the relative delivered price of coals in the region changed by similar amounts.

The results of the analysis for 1995 show a high degree of substitutibility between coal from the petition area and other coals available from Montana and Wyoming under either a limited or an unlimited leasing scenario. Changes in the relative total delivered price of coals shipped to Midwestern markets from Montana and Wyoming of approximately 10 percent or less result in production shifts either to or from the petition area. Given the assumptions about coal price and quality for coal developed in the petition area, the national cost of meeting 1995 coal demand under a limited leasing scenario could increase in a worst case by just over $100 million (1978 constant dollars), or by less than 0.001 percent, if the petition area were removed from production.

CHAPTER IV.

DESCRIPTION AND ANALYSES OF PETITION ALLEGATIONS

For purposes of analysis, the petition allegations and supporting statements have been separated into categories of (1) hydrology and (2) vegetation and soils. Some allegations are related to both hydrology and soils. These are responded to in both sections with appropriate cross-references.

This is a draft document. The purpose is to convey to the reader the extent to which the allegations have been analyzed and to indicate the direction of continued work on them.

This chapter summarizes the current status of the response to the petition allegations. The allegations are listed (by page and paragraph) under obvious groupings. Following the statement of allegations, the supporting statements from the affidavits are summarized, when appropriate. Finally, the direct analysis or response to the allegations is reported. When an analysis is still underway, the assumptions, methodologies to be used, additional data that is anticipated, etc., are presented.

The categories into which the petition's hydrology allegations and related statements have been organized are:

- Unusual hydrology of the petition area.
- Present quality and use of water.
- Long-term potential degradation of water quality.
- Cumulative impact on the Tongue River.
- Reclamation failure/increased sediment loads.
- Saline-seep development.

The categories into which the petition's soils allegations and related statements have been organized are:

- Nonreclaimability of soils because of salt and sodium problems (surface soils; overburden).
- Specific field sites referenced by petitioners (September 1980 sites; December 1980 sites).
- Smectite clays in soils.
- Shallow soils.
- Effect of sodium and salts on vegetation.
- Migration of salts after mining.

o Availability of salt-free soil materials.

o Translocation of salts.

o Erosion and reclamation failure.

A. HYDROLOGY

1. Introductory Comments

The major concern toward which the following allegations are directed is that "surface coal mining in the petition area could result in a substantial loss or reduction of long-range productivity of renewable resource lands, including water supply and food products." The petition contains statements in support of allegations. Some of these statements are included in order to set the stage for the analysis of the allegations.

2. Response to the Allegations

Unusual hydrology of the petition area

Page 10, paragraph 21, states:

> "The Tongue River generally has the best overall water quality among streams in the coal region of southeastern Montana. Bateridge affadavit, Exh. 8, paragraph 5." This statement was also made by D. H. Hickox in his affidavit in support of the petition.

Water quality in the Tongue River from the Wyoming boundary to the Yellowstone River is classified as B-2e (Montana Water Quality Rules, ARM 16.20.601 through 16.20.645). This moderately high classification requires the river to be maintained for purposes of: drinking, culinary, and food processing after conventional treatment; recreation and marginal propagation of salmonid fishes and associated aquatic life; and agricultural and industrial water supplies. The tributaries to the Tongue River in the petition area are all classified C-3, which is considered marginal for the uses listed above; degradation that will impact established beneficial uses is not allowable. Existing water quality of the Tongue River, as reported by Knapton and McKinley (1977) and Knapton and Ferreira (1980), meets nearly all of the EPA (1975, 1977) and Public Health Service standards (U.S. Department of Health, Education, and Welfare, 1962). The Tongue River Reservoir, developed for irrigation, regulates streamflow, reduces suspended sediments, and moderates the range of concentrations of other constituents (Knapton and McKinley, 1977), Thus, as water is released from the dam during the drier summer months, it dilutes and improves the lower quality baseflow (ground-water contribution).

Data from Woessner and others (1980), Knapton and Ferreira (1980), and the Northern Great Plains Resources Program (U.S. Department of Commerce, 1974) indicate that the total dissolved solids (TDS) levels and concentrations of other parameters make the Tongue River one of the better quality streams for southeastern Montana and western North Dakota. The tributaries, of lesser water quality, are considered to be more characteristic of southeastern Montana.

Page 10, paragraph 22, states:

> "The area addressed by the petition is one of particular significance in the recharge, transmission, and discharge of groundwater into the Tongue River. Bateridge affidavit, Exh. paragraph 9."

Recharge to ground waters in the petition area occurs where coarse rocky soils have sparse vegetative cover, which generally is in higher topographic areas. There, the moisture infiltrates and is weakly held by the coarse soil matrix and is thus able to move beyond the root zone to recharge ground waters. Additional recharge is believed to occur from leaky streams and from percolation of moisture into and through the coarse rocky clinker zones. Support for these concepts comes from individuals who are familiar with drilling the Fort Union Formation in the vicinity of the petition area (Wayne Van Voast and Max Botz, oral commun., 1981) as well as from a detailed hydrologic study done at the Westmoreland's Absaloka mine (Westmoreland Resources, 1978). The idea that the lowlands (areas of strippable coal) generally do not receive appreciable recharge is also supported by the fact that salt accumulations generally occur within 3 to 10 feet of the surface in the soil column. If deep percolation or recharge were occurring as the general case, then one would expect the salts to move down with the moisture.

An infiltration study (OSM unpublished data, 1980) was conducted by OSM staff on undisturbed soils and replaced topsoils over spoil at the West Decker mine. The results of the study indicate that (for those site-specific conditions) infiltration rates on topsoiled spoils were comparable to those of adjacent unmined soils. This indicates that the postmining soil surface can allow infiltration as part of the recharge process at a rate similar to that of the premining condition for areas that are not considered to be primary recharge zones. In the very permeable areas important to recharge (clinker and coarse soils) it is likely that reclamation efforts will not be able to restore premining infiltration rates.

Reduced runoff or recharge would likely result from mining and reclamation in those areas having large amounts of clinker, as alleged in Andrews' and Osborne's supporting affidavits. The amount of clinker in the petition area is not unusual in the northern Powder River Basin coal region. DSL and OSM have determined that about 20 percent of the petition area (38,860 acres) is clinker, of which only about 2.7 percent (1,060 acres) would be disturbed if all surface minable coal were extracted. Those clinker areas that may be disturbed are a small part of the total and are dispersed through the central portion of the petition area and the Otter Creek drainage. Thus, mining would not significantly affect recharge through this source.

DSL and OSM experience to date indicates that, where leaky streams provide part of the recharge to ground-water systems, there is no reason to believe that drainages restored after mining will not continue to lose water into the ground-water system.

Woessner and others (1980, v. I, p. 161) identified the ground-water discharge as a composite of "discharge from bedrock, clinker, and alluvial aquifers to the river" and that ground-water discharge to the Tongue River "occurred at various rates along selected reaches depending on the proximity to higher precipitation zones and presence of geologic materials with good aquifer characteristics." Woessner and others (1980) reported various ground-water inflow rates ranging from losses below Brandenberg to gains in excess of 1.2 cfs per river-mile upstream between Brandenberg and Birney Day School (Woessner and others, 1980, v. I, p. 161-165). (See table IV-1 and fig. II-1.) Woessner identified the greatest amount of ground-water discharge to the river along a reach between Birney Day School and 6 miles north of the Northern Cheyenne Reservation (Woessner and others, 1980, v. I, p. 165). Andrews and Osborne indicated that the Tongue River, "unlike most other streams in the region, receives measurable quantities of groundwater inflow." They estimated that the inflow ranges from 0.3 (in dry years) to 1.0 cfs per river-mile (in wet years). See paragraph 12 of Andrews affidavit and paragraph 7 of Osborne affidavit.

In conclusion, mining will have a slight impact on the portions of the petition area that are considered to be significant recharge areas (clinker in the upland areas, losing streams, and areas of coarse rocky soils). This portion of the Tongue River apparently has a greater gain in ground-water discharge that do other reaches of the river in Montana; however, current data from existing mines do not indicate that mine spoil will be a barrier to ground-water flow (Van Voast, 1978). Thus, DSL's/OSM's analyses indicate ground-water flow rates will continue to be the same after mining as before.

<u>Present quality and use of water</u>

Page 10, paragraphs 23, 24, and 25, state:

> "Surface water from the Tongue River irrigates 24,082 acres below the mouth of Hanging Woman Creek. Additional irrigable land has been identified along the Tongue River. See Exhibit 2 * * *. Residences, farms, and ranches, and the community of Ashland derive water from the Tongue River alluvium for domestic and agricultural use. Bateridge affidavit, Exh. 8, paragraph 7 * * *. The Tongue River member aquifers in the petition area are used by farms and ranches, which depend on it for survival. The ground water in these aquifers is barely adequate, both quantitatively and qualitatively, for domestic and agricultural uses. See Bateridge affidavit, Exh. 8, paragraph 7."

These paragraphs present baseline information rather than allegations and are therefore discussed in chapter II. They are included here in order that they may be read in context with the following allegation.

<u>Long-term potential degradation of water quality</u>

Page 10, paragraph 26, and page 11, paragraphs 27 and 28, allege:

> "Large scale mining in the petition area would cause significant regional changes. Most of the shallow groundwater in mined areas, plus part of the downstream regions, would be of marginal use for stock and undesirable for other uses. See Bateridge affidavit, Exh. 8, paragraph 12. Deterioration of marginal aquifers and degradation of water in the Tongue River alluvium would destroy the agricultural productivity of the affected areas * * *. Large scale mining in the area addressed by the

Table IV-1.--Mean ground-water discharge

in cubic meters per second per river kilometer
(cubic feet per second per river-mile)

STREAM REACH	USGS MEASUREMENTS Oct—Nov 1975 Seepage run: DAM CLOSURE 51 MEASUREMENTS		USGS MEASUREMENTS Nov 1977 Seepage run: NORMAL LOW FLOW 27 MEASUREMENTS	
	UNWEIGHTED	DISTANCE WEIGHTED	UNWEIGHTED	DISTANCE WEIGHTED
1 Dam to Birney Day Village area	0.008 (0.48)	0.009 (0.49)	0.005 (0.26)	0.005 (0.28)
2 Birney Day Village area to south of Brandenberg	0.015 (0.84)	0.011 (0.63)	0.022 (1.23)	0.018 (1.03)
3 Brandenberg area to Pumpkin Creek	0.006 (0.35)	0.008 (0.53)	0.009 (0.53)	0.007 (0.40)
4 Pumpkin Creek to Miles City	0.009 (0.56)	0.015 (0.82)	-0.003 (-0.15)	0.002 (0.11)
Entire Tongue River	0.010 (0.56)	0.011 (0.62)	0.008 (0.46)	0.008 (0.45)

> petition would have a deleterious effect on the water quality of the Tongue River water. Bateridge affidavit, Exh. 8, paragraphs 10 and 12 * * *. The effects on the Tongue River water quality from large scale mining in the petition area would appear gradually over a period of years and become observable only after it is too late to remedy the damage or cause. Water quality degradation from surface mining along the Tongue River would continue for hundreds of years, long after the mines cease production. See Bateridge affidavit, Exh. 8, paragraph 13."

The following techniques, used to make predictions of the quality of postmining ground and surface waters, are a best estimate of the impacts of mining, using limited data. In all cases, the assumptions are very conservative and generally consider worst-case conditions. The analyses also assume that the water quality impacts of all anticipated mining would occur at the same time. The calculations made are a reasonable use of the data that are available for consideration by the decisionmaker.

Bureau of Land Management's analysis for Otter Creek.--The BLM predicted the impacts of mining the proposed lease tracts on Otter Creek to (1) shallow (Tongue River Member) aquifers disturbed by mining and to (2) the alluvial ground water of Otter Creek (BLM's response to the petition, appendix C). They concluded that water from the spoil would contribute an average increase of 1,912 mg/L TDS, thus elevating TDS to 3,652 mg/L in shallow Tongue River Member aquifers. This increase would make waters considered good for livestock use before mining poor for such use after mining (McKee and Wolf, 1971). The ground-water quality in the spoil was then predicted to increase TDS levels in the Otter Creek alluvial system by an average of 1,650 mg/L. This would raise the average postmining alluvial water TDS levels to 4,700 mg/L. The present alluvial water quality, based on TDS levels, is considered to be poor for irrigation use (U.S. Salinity Laboratory, 1954) but is suitable for livestock water (McKee and Wolf, 1971). An increase in TDS to the predicted levels would render the alluvial water unfit for livestock water (McKee and Wolf, 1971). The salinity hazard for the alluvial water would be considered very high for irrigation use--as it is presently (U.S. Salinity Laboratory, 1954). However, the current practice of impounding higher quality spring runoff for use later in the year could still allow for irrigation and livestock watering.

Mining in the vicinity of Otter Creek was predicted to increase the TDS levels in the Tongue River 3 to 36 mg/L, depending on the flow rate. An increase of this magnitude, by itself, is not significant to the Tongue River water quality.

Salinity and flow modelling.--Van Voast predicted water quality changes for (1) the shallow Tongue River Member aquifers and (2) the Tongue River alluvium (appendix D). He further predicted postmining ground-water quality for shallow Tongue River Member aquifers in areas to be disturbed by mining or downgradient from mined areas. His projections, based on saturated extracts of the upper 50 feet of overburden (appendix E), show that the postmining spoil water quality would have a specific conductance (SC) equal to the premining SC (estimated at 3,300 µmhos/cm) plus that contributed by the spoils (estimated at 4,730 to 5,530 µmhos/cm). Using a conversion factor of 0.7 (appendix C), the postmining projected range in TDS is 5,621 to 6,181 mg/L compared with the estimated premining level of 2,310 mg/L. This change in quality would result in shallow ground waters in the Tongue River Member that, while considered good for livestock watering before mining, would be considered unfit for such use after mining (McKee and Wolf, 1971). Alternate sources of waters are available below the Lebo Shale. (See chapter II.)

As a part of DSL's/OSM's analysis of this allegation, mathematical salinity and flow modelling techniques were also used by Van Voast to estimate the effect of surface mining on the long-term degradation of water quality in the Tongue River alluvium (appendices A and D). Preliminary results indicate a predicted increase in SC of 920 to 2,090 µmhos/cm above the present mean levels of 1,490 µmhos/cm in the alluvial water along the river in the petition area. Using a conversion factor of 0.7, the conductance values convert to an average of approximately 644 to 1,463 mg/L TDS. When the predicted increase in TDS is added to the mean TDS level for the stream, the result is a range (after mining) of 1,687 to 2,506 mg/L TDS. These TDS levels present a very high salinity hazard for irrigation (U.S. Salinity Laboratory, 1954), although it would be considered as fair for livestock watering (McKee and Wolf, 1971).

<u>TDS modelling</u>.--Computer modelling of TDS levels was done to project long-term changes in river-water quality under several development scenarios. A model developed by U.S. Geological Survey (Woods, 1981) was chosen because it utilized available data and expanded upon previous models, such as that used by Woessner and others (1980) and Gherini and Summers (1979). Validation of this model indicated it closely tracked historic conditions. Much of the input data was derived from Knapton and Ferreira's (1980) studies in the Tongue River Basin.

A refined total minable acreage value will be used in the final and is expected to reduce projected Tongue River TDS levels. The final computer runs will only consider effects from anticipated mining upstream and from areas projected to be mined within the petition area. The input to the computer model will also be refined using projections of spoil water-quality data from overburden chemistry data from the OSM/DSL drilling project.

Several computer runs were made using different development levels. These include (1) the effects of mining along Otter Creek, (2) the effects from increased return flow due to agricultural developments, (3) the effects from intensive mining, and (4) the effects from both (a) increased return flow due to agricultural development and (b) intensive mining.

The initial computer run projected the effect of mining 33,731 acres of coal along Otter Creek. Preliminary results are shown in table IV-2. Projections show that mining the lease tracts near Otter Creek would substantially increase the dissolved solids concentration in Otter Creek, especially when streamflows are less than the mean. In the main stream Tongue River, the effects of such mining would likely be undetectable at mean streamflow. Even at reduced streamflow, irrigation water withdrawals from the main stream Tongue River would be of suitable quality after mining the proposed Otter Creek lease tracts (table IV-2).

A second computer run was used to project water-quality effects resulting from increase return flow from agricultural development due to enlargement of the Tongue River Dam. Table IV-3 shows the preliminary results of simulating instream discharge requirements for both the existing and the proposed reservoir. This projected reduction in streamflow to the instream discharge, in addition to the return flow, causes a projected rise in total dissolved-solids concentrations; however, the change in TDS will not cause the water to be unsuitable for its current uses.

Table IV-2.--Modeled dissolved-solids concentrations in reach 5[1] of the Tongue River and at the mouth of Otter Creek for nonmining[2] and mining[3] plans.

(Releases from the present and proposed Tongue River Reservoirs set at mean, minus 1 standard deviation, and instream)

Reservoir and month	Dissolved-solids concentration (mg/L)							
	Nonmining plan at mean streamflow		Mining plan mean streamflow		Mining plan at minus one standard deviation		Mining plan at instream flow	
	Reach 5	Otter Creek	Reach 5	Otter Creek	Reach 5	Otter Creek	Reach 5	Otter Creek
Present reservoir								
January	834	2,560	842	2,898	885	3,022	880	2,898
February	893	2,150	901	2,334	1,046	2,528	961	2,334
March	642	1,752	647	1,887	637	1,980	667	1,887
April	697	2,163	702	2,366	811	2,407	856	2,366
May	590	2,162	592	2,355	698	2,454	778	2,355
June	327	2,193	328	2,531	438	2,638	416	2,531
July	428	2,214	432	2,821	673	3,237	715	2,821
August	580	2,226	587	3,494	632	4,767	892	3,494
September	717	2,068	726	3,336	782	4,667	858	3,336
October	648	2,218	655	2,981	740	3,741	697	2,981
November	636	2,203	643	2,638	737	2,820	690	2,638
December	761	2,204	769	2,639	834	2,821	838	2,639
Proposed reservoir								
January	595	2,560	599	2,898	---	---	(4)	(4)
Februay	623	2,150	628	2,334	---	---	(4)	(4)
March	461	1,752	464	1,887	---	---	(4)	(4)
April	404	2,163	406	2,366	---	---	(4)	(4)
May	271	2,162	272	2,355	---	---	(4)	(4)
June	222	2,193	223	2,531	---	---	(4)	(4)
July	354	2,214	355	2,821	---	---	(4)	(4)
August	433	2,226	436	3,494	---	---	(4)	(4)
September	468	2,068	471	3,336	---	---	(4)	(4)
October	438	2,218	441	2,981	---	---	(4)	(4)
November	449	2,203	453	2,638	---	---	(4)	(4)
December	513	2,204	517	2,639	---	---	(4)	(4)

[1]See figure III-1, for the location of stream natural reaches.

[2]Nonmining plan includes irrigated acreages, from Montana Department of Natural Resourses.

[3]Mining plan includes irrigated acreages. Spoil leachates of 3,000 mg/L were discharged from 4,557 mined acres into reach 3 of Tongue River, and from 29,154 mined acres into Otter Creek.

[4]Dissolved-solids concentration same as "mining plan at instream flow" for present reservoir.

Table IV-3.--Modeled dissolved-solids concentrations in the Tongue River for present and increased levels of agricultural development for mean releases from the present and proposed Tongue River Reservoirs[1]

Reservoir and Month	Dissolved-solids concentration, (mg/L)									
	Present level[2] of agricultural development for Tongue River reaches					Increased level[3] of agricultural development for Tongue River reaches				
	1	2	3	4	5	1	2	3	4	5
Present reservoir										
January	559	668	765	817	834	559	667	762	812	829
February	591	703	828	884	893	590	700	822	874	884
March	585	627	675	643	642	585	627	675	645	646
April	570	619	673	690	697	571	621	676	696	703
May	494	523	558	581	590	495	528	569	601	614
June	267	286	305	320	327	267	289	310	331	339
July	237	293	341	403	428	239	305	370	474	521
August	279	354	423	538	580	282	375	482	734	867
September	411	487	560	672	717	415	511	620	832	928
October	493	551	597	637	648	495	557	610	663	682
November	501	558	607	630	636	502	559	609	637	648
December	577	654	718	753	761	577	653	716	755	768
Proposed reservoir										
January	420	484	544	581	595	421	486	547	587	601
February	422	488	567	608	623	422	489	569	611	627
March	368	411	455	454	461	368	412	457	459	466
April	310	342	376	394	404	310	343	378	398	409
May	221	236	254	265	271	222	238	257	270	277
June	195	204	212	219	222	195	205	214	222	226
July	275	301	321	345	354	276	305	331	363	376
August	321	355	383	421	433	323	363	400	458	478
September	346	381	411	452	468	347	389	428	487	511
October	354	386	411	433	438	355	389	417	443	450
November	366	400	430	445	449	367	401	432	449	454
December	399	446	485	507	513	399	446	486	510	516

[1]See figure III-1 for the location of stream reaches.

[2]Present level irrigated acreage: reach 1 = 1,000; reach 2 = 3,000; reach 3 = 3,500; reach 4 = 5,000; reach 5 = 1,700; Hanging Woman Creek = 1,225; Otter Creek = 785; Pumpkin Creek = 2,875.

[3]Increased level irrigated acreage: reach 1 = 1,490; reach 2 = 4,470; reach 3 = 5,250; reach 4 = 7,450; reach 5 = 2,540; Hanging Woman Creek = 1,225; Otter Creek = 785; Pumpkin Creek = 2,875.

The third model run incorporated more intensive (potential) mining levels listed in table IV-4. The results of this simulation are shown in tables IV-5 and IV-6. With the proposed reservoir releasing mean streamflow, the range of dissolved-solids concentrations in reach No. 5 (fig. IV-1) is 225 to 647 mg/L with mining and 222 to 623 mg/L without mining. These increased TDS levels are insignificant to irrigation; however, the concentrations rise appreciably when the flow is reduced to minimum instream requirements set by the State for wildlife purposes. At this lower flow rate, the salinity hazard for irrigation would be high to very high throughout the entire growing season.

Water quality in the Tongue River at mean streamflow, under a scenario of intensive mining along both the Tongue River and Otter Creek would remain useable for irrigation at these elevated dissolved-solids concentrations. Intensive mining and increased agricultural development would combine to indicate that during the early part of the growing season (May through July), the additions of TDS are minor (tables IV-7 and IV-8). However, in August and September (during periods of low flow), the projected increases in TDS significantly elevate the salinity hazard for irrigation.

The analyses thus far indicate that the shallow Tongue River Member aquifers directly affected by, or downgradient from, mining will have the greatest increase in TDS due to mining. Waters from these shallow aquifers that were considered good for livestock use prior to mining would be poor to unsuitable for livestock use after mining. In these areas, the water supply that would be necessary to support the postmining land use would have to be obtained from deeper sources, possibly below the Lebo Shale. (See discussion of water supplies in chapter II.) Completing wells into the deeper aquifers would be more expensive owing to the increased drilling and pumping depth and also the unstable nature of spoil making drilling more difficult.

Alluvial ground waters were predicted to have the next greatest increase in TDS as a result of mining. The salinity hazard of the alluvial waters for irrigations use in both drainages would remain high or would be increased to very high after mining. The suitability of the alluvial waters for livestock use, considered good prior to mining, would remain good along the Tongue River and would degrade to fair along Otter Creek after mining.

The estimates of water quality summarized above are not expected to be reduced (based on the refinement of overburden quality and extent of mining data now available).

Preliminary projections indicate that mining will have the greatest effect on the Tongue River during periods of low flow (August through September) or when water levels are reduced to the instream flow reserved for aquatic life. The evaluation of the effects of increased development (including maximum mining and/or irrigation along the Tongue River) indicates that the quality of flow in the Tongue River would, during periods of low flow, be considered a high to very high salinity hazard for irrigation (August through September). The projected worst-case impacts are considered long term. Because an extremely high estimate of recoverable coal acreage was used, actual conditions would be somewhat less than projected.

Table IV-4.--Mined acreage and spoil leachate dissolved-solids concentrations for intensive mining plans

Reach[1]			Potential lease tracts			
Name	Mined acreage[2]	Dissolved-solids concentration of leachate[2] (mg/L)	Tract name	Acreage	Number of wells and springs sampled	Mean dissolved-solids concentration (mg/L)
Tongue River, 1	10,000	1,600	Birney	10,024	49	1,048
Tongue River, 2	4,200	4,500	Montco	4,200	2	2,990
Tongue River, 3	4,600	2,350	Ashland (Coalwood)	4,577	15	1,570
Tongue River, 4	18,000	2,900	Sweeney-Snyder,	1,062	12	2,317
			Foster Creek	16,904	30	1,906
Tongue River, 5	0	0	---	---	---	---
Hanging Woman Creek	21,600	4,000	Hanging Woman	21,620	30	2,654
Otter Creek	52,300	3,850	Ashland (Decker-Birney),	6,240	34	2,270
			Otter Creek,	20,626	34	2,270
			Ashland (Coalwood),	1,288	15	1,570
			Moorhead	24,132	57	2,967
Pumpkin Creek	8,900	3,000	Pumpkin Creek	8,900	29	2,012

[1]See figure III-1 for location of stream reaches.

[2]These values used in simulations of intensive mining plans.

Table IV-5.--Modeled dissolved-solids concentrations in reach 5[1] of the Tongue River for nonmining and mining plans[2,3]

(Releases from the present and proposed Tongue River Reservoirs set at mean, minus 1 standard deviation, and instream)

Month	Dissolved-solids concentration (mg/L)			
	Nonmining plan at mean streamflow	Mining plan at mean streamflow	Mining plan at minus one standard deviation streamflow	Mining plan at instream flow
Present reservoir				
January	834	876	929	933
February	893	935	1,105	1,004
March	642	665	667	679
April	697	718	843	890
May	590	601	716	715
June	327	334	456	494
July	428	451	728	1,040
August	580	623	683	1,307
September	717	763	837	1,091
October	648	683	789	777
November	636	669	786	762
December	761	803	882	900
Proposed reservoir				
January	595	619	---	(2)
February	623	647	---	(2)
March	461	475	---	(2)
April	404	415	---	(2)
May	271	276	---	(2)
June	222	225	---	(2)
July	354	363	---	(2)
August	433	449	---	(2)
September	468	487	---	(2)
October	438	455	---	(2)
November	449	467	---	(2)
December	513	535	---	(2)

[1]Mining plan conditions listed in table IV-4. Irrigated acreages as listed from the Montana Department of Natural Resources.

[2]Dissolved-solids concentrations same as "mining plan at instream flow" for present reservoir.

Table IV-6.--Modeled dissolved-solids concentrations for intensive mining and mean releases from the proposed Tongue River Reservoir[1]

Month	Dissolved-solids concentration (mg/L)							
	Tongue River reaches [2]					Hanging Woman Creek	Otter Creek	Pumpkin Creek
	1	2	3	4	5			
January	421	490	560	603	619	2,629	3,338	1,681
February	423	495	584	630	647	2,435	2,574	1,006
March	369	415	465	467	475	1,960	2,063	934
April	310	345	384	404	415	2,441	2,630	891
May	221	238	257	269	276	2,482	2,607	934
June	195	205	215	222	225	2,566	2,971	1,320
July	275	303	327	353	363	2,443	3,611	1,572
August	322	358	393	435	449	3,297	5,144	7,007
September	346	385	422	468	487	4,474	4,986	1,562
October	355	391	423	448	455	3,474	3,974	6,126
November	367	405	442	461	467	3,155	3,205	6,988
December	400	451	499	527	535	2,946	3,206	7,007

[1] Irrigated acreages as listed from the Montana Department of Natural Resources.

[2] See figure III-1 for location of stream reaches.

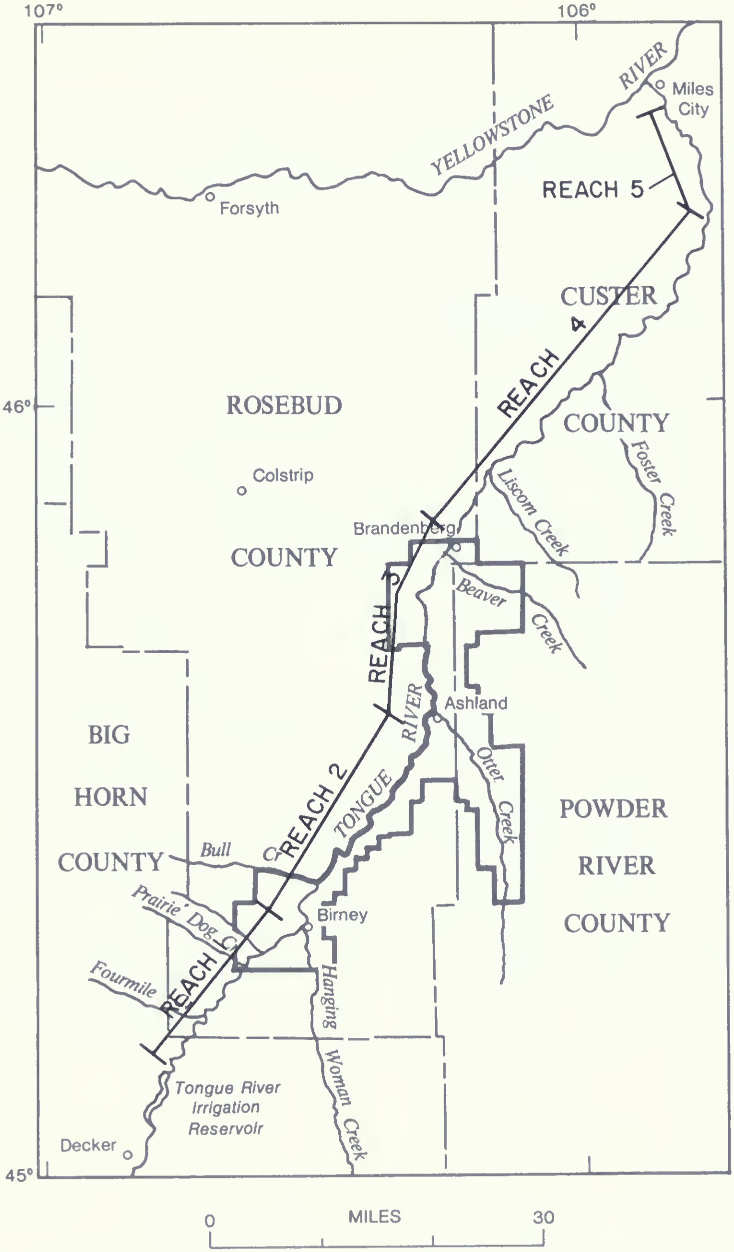

Figure IV-1.--Tongue River reaches used in the Geological Survey surface water model.

Table IV-7.--Modeled dissolved-solids concentrations in reach 5[1] of the Tongue River for nonmining with present irrigation plans[2] and intensive mining with increased irrigation plans[3]

(Releases from the present and proposed Tongue River Reservoirs set at mean, at minus 1 standard deviation, and at instream flow)

Month	Dissolved-solids concentration (mg/L)			
	Nonmining, present agriculture plan at mean streamflow	Mining, increased agriculture plan at mean streamflow	Mining, increased agriculture plan at minus one standard deviation streamflow	Mining, increased agriculture plan at instream flow[3]
Present reservoir				
January	834	868	915	920
February	893	923	1,069	986
March	642	668	671	682
April	697	724	851	897
May	590	624	787	815
June	327	347	517	542
July	428	551	1,009	1,353
August	580	935	884	2,057
September	717	989	1,008	1,353
October	648	717	826	824
November	636	681	799	790
December	761	809	890	927
Proposed reservoir				
January	595	624	---	(4)
February	623	650	---	(4)
March	461	480	---	(4)
April	404	420	---	(4)
May	271	282	---	(4)
June	222	229	---	(4)
July	354	387	---	(4)
August	433	497	---	(4)
September	468	532	---	(4)
October	438	467	---	(4)
November	449	471	---	(4)
December	513	538	---	(4)

[1]Irrigated acreages as listed from the Montana Department of Resources.

[2]Mining plan conditions listed in table IV-4. Increased level irrigated acreages: reach 1 = 1,490; reach 2 = 4,470; reach 3 = 7,250; reach 4 = 7,450; reach 5 = 2,540; Hanging Woman Creek = 1,225; Otter Creek = 785; Pumpkin Creek = 2,875.

[3]See figure III-1 for location of stream reaches.

[4]Dissolved-solids concentrations same as "mining, increased agriculture plan at instream flow."

Table IV-8.--Modeled dissolved-solids concentrations for intensive mining with increased irrigation and mean releases from the proposed Tongue River Reservoir[1]

Month	Dissolved-solids concentration (mg/L)							
	Tongue River reaches[3]					Hanging Woman Creek	Otter Creek	Pumpkin Creek
	1	2	3	4	5			
January	422	492	563	607	624	2,629	3,338	1,681
February	423	496	585	632	650	2,435	2,574	1,006
March	369	416	467	471	480	1,960	2,063	934
April	310	346	386	408	420	2,441	2,630	891
May	222	239	260	274	282	2,482	2,607	934
June	195	206	216	225	229	2,566	2,971	1,320
July	276	307	337	372	387	2,443	3,611	1,572
August	323	366	411	474	497	3,297	5,144	7,007
September	348	393	440	505	532	4,474	4,986	1,562
October	355	394	428	458	467	3,474	3,974	6,126
November	367	406	444	465	471	3,155	3,205	6,988
December	400	452	500	529	538	2,946	3,206	7,007

[1]Mining plan conditions listed in table IV-4.

[2]Irrigated acreages: reach 1 = 1,490; reach 2 = 4,470; reach 3 = 5,250; reach 4 = 7,450; reach 5 = 2,540; Hanging Woman Creek = 1,225; Otter Creek = 785; Pumpkin Creek = 2,875.

[3]See figure III-1 for location of stream reaches.

Cumulative impact on the Tongue River

The allegations below address mining upstream from the petition area, the new Tongue River Dam, and additional water consumption, all of which might worsen the effects of coal mining on the Tongue River.

Page 11, paragraphs 29 and 30, allege:

> "Reduced stream flows in the Tongue River which would result from climatic conditions and increased withdrawals upstream for irrigation, municipal, or industrial uses would accelerate the decline in water quality. See Bateridge affidavit, Exh. 8, paragraph 16 * * *. The State of Montana is considering several alternatives for repairing the Tongue River Dam which would entail lowering the firm annual water supply for several years. Should this occur, reduced streamflows would aggravate the degradation of water quality in the Tongue River. See Bateridge affidavit, Exh. 8, paragraphs 14 and 16."

The previously described computer runs of the U.S. Geological Survey model have taken into account the most likely alteration to the Tongue River Dam presented to the 1981 session of the Montana Legislature. The conclusions based on these preliminary results indicate that the effects of the modified Tongue River Dam and increased irrigation would have the greatest impact during periods of low flow (August through September). The alterations to the Tongue River Dam should not lower firm annual yield for a number of years. No projections of increased industrial withdrawals have been made due to a lack of information to support additional consumption. There is also a lack of data on increased municipal withdrawals. The assumption is made that 7,000 additional acres would be irrigated with the additional water stored by the new dam (Rick Bondy, oral commun., 1981). Additional computer runs will be made as scenarios are refined to include other developments to further evaluate the effect of reduced streamflows on water quality.

Page 11, paragraph 31, and page 12, paragraphs 32 and 33, allege:

> "Strip mining operations are currently taking place on the Tongue River basin upstream from the petition area at the following mines in Montana and Wyoming: Decker East, Decker West, Spring Creek, Big Horn, Ash Creek, and Welch * * *. Additional mines are proposed or expected in the Tongue River basin upstream from the petition area. These include North Decker, Consol CX Ranch, PKS CX Ranch, Shell Young's Creek, and Amoco, with a total anticipated annual production capacity of 32.4 million tons per year by 1990 * * *. Mines upstream from the petition area, both ongoing and likely additional operations, would compound the deleterious effects on the Tongue River from mining in the petition area. See Bateridge affidavit, Exh. 8, paragraph 16."

Van Voast (1975), at the Montana Bureau of Mines and Geology, predicted the water quality impacts of mining at the Decker West, East, and North mines on the Tongue River (table IV-9). These projected impacts are being incorporated into

Table IV-9.--Monthly averages for discharge and water quality of the Tongue River near Decker, before and after mining[1]

(Source: Van Voast and Hedges, 1975)

Month	Mean discharge (cfs)	Averages from monthly analyses composited by discharge				
		Dissolved solids (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	SAR[2]
January	196 (200)	736 (763)	32.0 (36.8)	68.7 (70.4)	47.6 (48.3)	.8 (.9)
February	295 (299)	684 (703)	30.1 (33.4)	63.9 (65.1)	44.3 (44.8)	.7 (.8)
March	440 (444)	764 (776)	43.5 (45.6)	67.6 (68.4)	49.9 (50.2)	1.0 (1.1)
April	413 (417)	759 (772)	44.8 (47.0)	65.0 (65.9)	49.5 (49.8)	1.1 (1.1)
May	1,253 (1,257)	476 (481)	22.1 (22.9)	47.9 (48.2)	26.7 (26.9)	.7 (.7)
June	1,969 (1,973)	287 (291)	12.5 (13.0)	31.2 (31.4)	14.1 (14.2)	.5 (.5)
July	504 (508)	489 (501)	27.0 (28.9)	45.1 (45.9)	29.6 (30.0)	.8 (.9)
August	187 (191)	715 (744)	42.7 (47.6)	60.5 (62.5)	46.7 (47.5)	1.1 (1.2)
September	276 (280)	643 (664)	33.9 (37.3)	58.5 (59.9)	43.3 (43.9)	.9 (.9)
October	291 (295)	686 (705)	33.0 (36.3)	58.4 (59.7)	48.8 (49.3)	.8 (.9)
November	256 (260)	716 (737)	37.4 (41.1)	56.4 (57.9)	52.1 (52.6)	.9 (1.0)
December	203 (207)	742 (768)	35.7 (40.3)	67.9 (69.6)	50.5 (51.2)	.8 (.9)
Annual	524 (528)	517 (529)	25.8 (27.7)	46.5 (47.3)	31.7 (32.1)	.8 (.8)

[1]These estimates address the effects of the East, West, and North Extension Decker mines on discharge and water quality of the river. The first figure in each column shows the values actually observed from 1965 to 1973 for discharge or water quality of the Tongue River; the second figure (in parentheses) shows hypothetical postmining values due to ground-water inflow from the mined area. Values assumed for ground water flowing into the Tongue River after mining are as follows: maximum possible postmining ground-water flow (estimated), 3.6 cfs; dissolved solids concentration, 2,250 mg/L; sodium concentration: 300 mg/L; calcium concentration, 164 mg/L; magnesium concentration, 88 mg/L; and sodium adsorption ratio (SAR), 4.9.

[2]SAR = sodium adsorption ratio.

a run of the U.S. Geological Survey model by using the projected monthly altered water qualities as the input for the model (outflow from the Tongue River Dam).

Ongoing work at the Montana Bureau of Mines and Geology is being done to project the impacts of all anticipated mining in the Decker area and, as this work becomes available, it will be used in the Geological Survey model to provide insight into both the impacts of mining within and upstream from the petition area.

A review of mining and reclamation plans submitted to OSM and DSL indicates that the following mines are proposed for the Tongue River valley:

Mine*	Operator	State	Status
North Decker	Decker Coal Co.	Montana	Mine plan submitted.
Consol CX Ranch	Consolidation Coal	Montana	Baseline investigations underway; application anticipated, fall 1981.
PKS CX Ranch	Peter Kiewit and Sons	Montana	Baseline investigations underway.
Young's Creek	Shell Oil Co.	Montana (Crow Indian Reservation)	Proposed: draft leasing EIS published, February 1981.
Welch No. 1	Sheridan Enterprises, Inc.	Wyoming, Tongue River, T. 57 N., R. 84 W., secs 2 and 3	State Permit No. 497, approved, November 1979.

*In addition, Amoco has indicated an interest in mining an area along the upper reaches of Hanging Woman Creek.

Therefore, it is not possible to draw a conclusion at this time; a response to this allegation will be made in the final evaluation document.

Reclamation failure/increased sediment loads

Page 9, paragraph 20, states:

> The combination of poor soil structure and the lack of vegetative cover which would result if reclamation fails would increase the susceptibility of soils to wind and water erosion. Opper affidavit, Exh. 9, paragraph 18."

Page 12, paragraph 34, alleges:

> "If reclamation attempts fail in the petition area, increased sediment loads might result which would further degrade water quality in the Tongue River. See Bateridge affidavit, exh. 8, paragraph 15. See also Opper affidavit, Exh. 9."

Opper concluded, based on the assumptions mentioned in paragraph 20, that revegetation will be unsuccessful due to the high percentage of sodic clays in the soils and overburden. The soils portion of this chapter concludes that the allegations, to the effect that sufficient quantities of salt-free soils and overburden needed for revegetation cannot be found in the petition area, cannot be substantiated.

OSM unpublished data from 40 infiltration and run-off plot observations, using a Rocky Mountain Infiltrometer, indicate that, after 5 years from initial seeding, under the site-specific conditions at the West Decker mine, reclamation efforts can be successful in restoring infiltration rates and stabilizing topsoils comparable to that of unmined adjacent areas. The sites selected for observation had gradual slopes, loamy textured soils, and vegetative covers all representative of the area.

Andrews (paragraph 13 of his affidavit) indicated that the annual gain in suspended load is "only 40 tons per square mile in the reach of the Tongue River between the dam and Brandenberg, whereas the gain is 60 to 80 tons downstream of Brandenberg." He compared these gains to the Powder River at Arvada (500 tons/mi^2) and to the Bighorn River near Hardin (300 tons/mi^2). Knapton and Ferreira (1980) pointed out that the Tongue River Reservoir acts as a sediment trap, and thus the river downstream from the dam is relatively free of suspended solids (Knapton and Ferreira, 1980, p. 7). Their data show an increase in suspended solids in the downstream direction such that, at Miles City, the concentrations range from 5 to 4,360 mg/L with a mean of 428 mg/L (Knapton and Ferreira, 1980, p. 32). (See also Knapton and McKinley, 1977; U.S. Geolgical Survey and Montana Department of State Lands, 1979; Missouri River Basin Comprehensive Framework Study, 1971, v. 7, p 20). Knapton and Ferreira also stated that only Sarpy and Armells Creeks had lower mean concentrations in the study area.

Knapton and McKinley (1977) stated that the Tongue River Reservoir largely controls the amount of suspended sediment in the river near the confluence of Hanging Woman Creek. However, they noted that by the time the river reaches Miles City sediment has become readily available, particularly when streamflows exceed 500 cfs. At Miles City, streamflow is frequently this high, while upstream flows are generally lower. It appears that at 500 cfs the river begins to be able to pick up bed and bank materials, which would explain the sudden increase in sediment concentrations at flow rates above this threshhold. In addition, the textural analyses of sediment samples indicate that at high flow 80 percent of the sediment consisted of silt and clay. It takes more energy for a stream to entrain the extremely fine sediment fractions, which also supports the concept that sediment loads are more closely related to streamflow (particularly above 500 cfs) than to the amount of clinker in the basin as the petition alleges. In addition, lithologic changes (Lebo Shale and Tullock Members of the Fort Union Formation) occur below Brandenberg Bridge that could make sediment yield higher than in the petition area. Runoff rates and sediment yields are influenced by many factors, of which clinker is but one. The petition area does not necessarily stand out as having high infiltration rates and low sediment yields directly related to the amount of clinker present. In conclusion, it is not clear that low sediment yields for the portion of the Tongue River that traverses the petition area are closely related to the amount of clinker present in the area.

In addition to the petition items, the Andrews affidavit (No. 20) states that the during-mining sediment-control measures would prevent increases in suspended sediments being contributed off active mine areas. However, the affidavit further contends that in the long term (after removal of sedimentation ponds, etc.), increased concentrations in suspended solids are inevitable. The reasons cited are the unconsolidated fine-grained spoils which would be easily eroded when headcuts develop.

Headcutting is a natural phenomenon in the semiarid West (Patton and Schumm, 1975) and almost every drainageway flows through accumulations of unconsolidated valley fill (not much different than unconsolidated spoil). If drainages are correctly designed (according to Montana's surface mining rules), reclamation of drainageways should be successful. Reclamation may even be considered successful if headcuts form, as long as the sediment yield from the reclaimed area was not greater than the premining rate. The fact that the postmining topography generally has gentle slopes and less potential energy available for erosion provides additional support that erosion and sediment yield might not be accelerated as a result of mining.

A mining operations compliance with Montana's law and surface mining rules regarding reclamation and sedimentation will prevent increased erosion and sediment yield resulting from acceleration mining. It should be noted that, in Montana, if a reclamation failure occurs, the company involved risks not only the monetary loss of its bond, but also its ability to ever mine coal in the State again.

It appears that the potential for reclamation success in the petition area is good, and the risk of a reclamation failure no greater than at other mines permitted to date in Montana. (See the accompanying section, Soils and Vegetation.)

Saline-seep development

Page 9, paragraph 19, states:

> "The effects of salt translocation often take decades to manifest themselves. Evidence indicates that burial of salty or sodic material by relatively nonsaline topsoil may only postpone consequences (Opper affidavit, exhibit 9, paragraph 11). Surface mining and reclamation technology in the Nothern Great Plains is too recently developed to lend the long term perspective necessary to assess the effects of burying sodic materials."

The soils portion of this chapter responds to the upwards translocation of salts in soils. Several points concerning the potential for saline seeps as a result of mining were raised in the affidavits (Osborne, paragraph 14; Andrews, paragraphs 14, 21, and 22) and are addressed here. The affidavits state that saline seeps develop gradually, and, therefore, it is not surprising that no saline seeps are known to be associated with mine spoils in Montana and Wyoming. They further contend that saline seeps are likely to form in reclaimed spoils areas that are hummocky as a result of discharge and evaporation from small ground-water flow systems that develop. According to the Andrews affidavit (No. 21), these saline seeps would result in significant productivity declines.

Saline seeps form where shallow ground water is held near the soil surface and water losses occur due to evapotranspiration, leaving a concentration of salts that had previously been in solution. The scenarios of saline-seep development commonly conveyed involved fallow crop rotation where excess moisture becomes available and is lost to deep percolation. The excess moisture moves down to an impermeable saline shale, where it takes salts into solution and begins to migrate laterally to a discharge point. At the discharge point, evapotranspirative losses cause the concentration of salts, resulting in a saline seep. It is important to note that although the concentration of dissolved constitutents plays a role in the formation of saline seeps, the overriding factors are the geologic/hydrologic conditions that allow the slow evaporative loss of shallow ground water (Marvin Miller, Montana Bureau of Mines and Geology, oral commun., 1981). In some circumstances saline seeps have been documented where the contributing ground waters contain as little as 1,000 mg/L TDS (Montana Bureau of Mines and Geology staff, oral commun., 1981).

In order for a saline seep to develop, excess moisture must first be available to percolate beyond the root zone. The permanent diverse vegetative communities required by Montana's laws should root at various depths and be very effective at utilizing all the moisture supplied to the soil profile. So, in general, not much moisture will percolate beyond the root zone. In support of this, salts are observed to accumulate in well-developed natural soils profiles in the area, at about 30 to 50 inches in depth. Apparently, native vegetation has utilized the additions of moisture and prevented the downward movement of moisture (and salts) below the root zone. The overburden data (see the discussion of overburden, under Vegetation and Soils, in this chapter) for the petition area indicate that there is, on the average, more than 8 feet of suitable overburden materials available over the area. Thus, there should be little problem with plants attaining their full rooting depth.

There will be some limited circumstances, such as a snowbank on the lee side of a ridge, where moisture would escape the root zone and be available to contribute to a saline seep. In these circumstances, the excess moisture must be able to move over an impermeable zone to a discharge point or be held at the surface in order for a saline seep to develop. As mentioned in the previous paragraph, at least 8 feet of suitable material are available, and would not inhibit movement of water according to the criteria of Dollhopf and others (1981). Therefore, saline seeps would not likely form through the perching of shallow ground water because such seepage would require saturation of the upper several feet of material. It is doubtful that there would be sufficient moisture available to effect such saturation, unless the moisture were concentrated in a valley bottom.

Stream courses are required by Montana's surface mining rules to be restored to the postmining landscape and, as such, will serve as a ground-water low or discharge area for the postmining water table. Under these circumstances, the spoil water levels would be drawn down below the surface in areas surrounding the stream course and the continual movement of ground waters would lessen the potential for salts to accumulate. In addition, any salts accumulating near the surface from plant utilization of shallow ground water should be periodically flushed by soil moisture moving down through the profile. The formation of saline seeps as a result of high spoil water tables can therefore be avoided through design considerations in the postmining topography.

The final situation envisioned where saline seeps could form following mining would be ground-water discharge points downgradient from, within, and adjacent to mining, creating the opportunity for evaporation of water and concentration of salts. In the postmining environment, a spoil aquifer will form at the base of the pit, and ground waters will move laterally (downgradient) to a discharge area. The primary ground-water flow into the spoil is expected to be lateral from adjacent unmined areas (not from vertical recharge). (See discussion under "Long-term potential degradation of water quality," petition paragraphs 26, 27, and 28). At present, the movement of ground water downgradient indicates that the postmining direction of ground-water flow would again be toward the Tongue River, where the opportunity for discharge occurs along coal or clinker outcrops. Saline seeps are primarily a result of evaporation and the concentration of salts. Thus, existing saline seeps in the area would be a good indication of the likelihood of postmining saline-seep development. The Soil Conservation Service soils maps for the petition area do not show any significant saline seeps for the petition area (Montana Department of State Lands files on the Saline Seep Program, 1974-75). Therefore, the opportunity for saline-seep development at discharge points does not appear likely.

In summary, several scenarios of saline-seep development as a result of mining have been considered, and the conclusions do not support the allegation that large-scale saline seeps will develop after mining.

B. VEGETATION AND SOILS

1. Introductory Comments

In the evaluation of the allegations of the petition, the following specific information on the soils and overburden of the petition area were utilized: Powder River Area Soil Survey (U.S. Department of Agriculture and others, 1971); Rosebud County Soil Survey (U.S. Department of Agriculture, Soil Conservation Service, unpublished); Montco mine permit application (Montco, 1980d); several Energy Minerals Resource Inventory Area (EMRIA) studies in the Otter Creek area (U.S. Bureau of Land Management, 1975; Bureau of Land Management and Bureau of Reclamation, 1977a, b, 1978a, b, c), and unpublished overburden data in the Cook Creek area (Montco, 1980c). The Western Energy and Land Use Team's (WELUT) computer program (U.S. Fish and Wildlife Service, Fort Collins, Colorado) was utilized to summarize and display the Soil Conservation Service (SCS) soil survey information in various ways useful to the evaluation.

With the cooperation of the U.S. Geological Survey, additional overburden drilling was undertaken in the petition area, especially in those areas where information was nonexistent or sparse. This project resulted in the taking of some 800 overburden samples, which were sent to a commercial laboratory for physio-chemical characterization.

DSL and OSM investigated the vegetation and soils within the petition area as well as those specific sites examined and described by the petitioners in support of their allegations. Samples of various soils were taken throughout the petition area for physical and chemical analyses.

All the above-referenced data, as well as the additional data collected on overburden and soils, are available for review in the public record. Sample sites are indicated in figure IV-2.

Criteria utilized in categorizing the suitability of soils and overburden for reclamation purposes are found in the National Soils Handbook (U.S. Department of Agriculture, 1978), State soil unsuitability guidelines (DSL, 1977), and Dollhopf and others (1981).

2. Response to the Allegations

The format of the following discussion first reiterates the petition allegations and salient features of the supporting affidavits submitted by Richard Opper. A response to each allegation is then made.

Non-reclaimability of soils because of salt and sodium problems

Page 8, paragraphs 12 and 13, allege:

> "Reclamation of the area is not technologically or economically feasible because of a combination of sodic and/or salty soils and shallow recoverable topsoils. See Opper affidavits, Exhibits 9 and 9a * * * . The physical and chemical characteristics of soils and overburden in the petition area are inadequate for revegetation. Available data indicate that salt and sodium problems are widespread throughout the petition area. Opper affidavits, Exh. 9, paragraphs 12, 13, 14, 16 and Exh. 9a, paragraphs 10, 16, 17. Salt and sodium levels at some sites in the petition area are extraordinarily high. Opper affidavits, Exh. 9, paragraph 19; Exh. 9a, paragraphs 8, 9, 12, 14, 15."

Surface soils.--Evaluation of the available SCS soil surveys indicates several mapping units described as either saline or sodic, or both, which, because of the degree of salinity or sodicity described, would render these soils doubtful sources of suitable material for reclamation. Preliminary analysis of the areal extent of these soils within the general acreage of strippable coal reserves in the petition area indicates that these soils occupy only about 1.5 percent of the area, or about 2,340 acres.

However, other soils are variously affected by salts and sodium as evidenced by the soil survey on the Montco mine project area (1980d) and various Bureau of Land Management EMRIA studies on Otter Creek (U.S. Bureau of Land Management, 1975; U.S. Bureau of Land Management and U.S. Bureau of Reclamation, 1977a, b, 1978a, b, c). The Montco information contains a "best case" summary of volumes of suitable soil material on 9,005 acres of the Montco project area (1980d, appendix E, table E1-2). Calculations based on this table of the "best" material available for a grassland type of revegetation suggest that an average of 17 inches of suitable surface soil are present for salvage and use in reclamation. Salvage of this material would be required of any mining operation pursuant to State surface mining rules (Montana ARM 26.4.304 13). An even

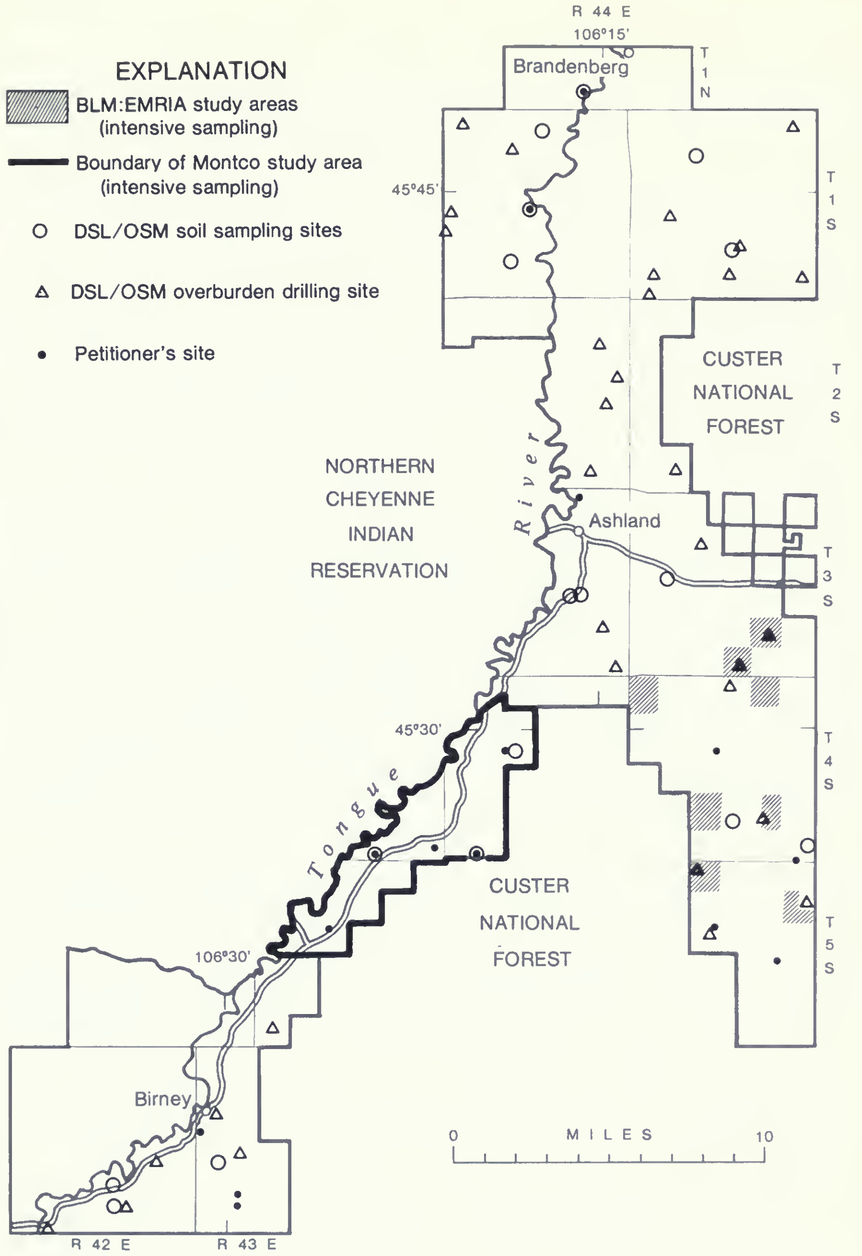

Figure IV-2.--Sample sites for data collection.

greater volume of soil would be available in the Montco area if certain soils with abundant coarse fragments were salvaged for special reclamation purposes, such as for the reestablishment of ponderosa pine and skunkbush sumac.

U.S. Bureau of Land Management and U.S. Bureau of Reclamation soils data for about 8 sections of land in the Otter Creek drainage (see EMRIA studies referenced above) reveal some soils as being highly saline (EC's greater than 15 millimhos per centimeter (mmhos/cm)) and/or moderately sodic (SAR's up to 20). However, interpretations of these data suggest a wide range in the thicknesses of suitable surface material (0 to 60 inches). Also, classification of these soils for reclamation purposes in all but the 1975 study site indicated that 24 to 54 percent of lands involved were Class I or II, which are defined in the studies as those lands having the soils best suited for reclamation. Thus, in the Otter Creek area, it would appear that more comprehensive sampling and analysis would be necessary as a part of any future site-specific mining and reclamation plan development to identify the location and to define the volume of suitable surface soil materials for reclamation purposes. This would be required pursuant to the State surface mining rules (Montana ARM 26.4.304(13)).

DSL and OSM collected soil samples from 18 sites in the petition area, representing a range of materials from shallow, residual soils on steep uplands to deep, alluvial soils on flood plains. Laboratory analysis of these samples (available in the public record) revealed excessive levels of salt and/or sodium at four of the sites. All four sites represented deep alluvial materials, and the data indicated that 1 to 3 feet of suitable soil material was available at these sites despite the elevated salts which occurred in the subsoils. Two of these four sites were dominated by greasewood and were located in the SCS mapping unit "yamac loam, alkali." Because of the results of DSL's/OSM's sampling at these two sites, it can reasonable be concluded that suitable soil volumes within this mapping unit are highly variable. As indicated previously, the "yamac loam, alkali" occurs in a very small proportion of the petition area. Only further intensive sampling of this type of mapping unit would indicate the average availability of suitable soil material.

Soils data for the other 14 sites sampled by DSL and OSM indicated no apparent limitations and would represent suitable materials for revegetation.

Overburden.--Montco has presented overburden data for 62 drill holes in its project area (Montco, 1980d, v. N, tables N-13 through N-91). Highly sodic (SAR's of 40 and above) and fine-textured materials (clay contents exceeding 50 percent) were identified in various locations and strata. However, examination of the data revealed that an average depth of about 20 feet to over 50 feet of suitable and reasonably accessible overburden or interburden would be available in the various areas for which Montco has indicated long-range mining interests. Use of this suitable overburden and interburden would be required of Montco in order to meet the basic 8-foot burial requirement of material not conducive to revegetation, such as sodic, saline, and very fine textured materials (Montana ARM 26.4.506).

The location of suitable geologic materials on the Montco project area varies from overburden to interburden and varies among drill holes. The data indicate no suitable material for some drill holes. Thus, the ultimate decision on reclaimability according to State and Federal regulations would necessitate evaluation of a site-specific mining and reclamation plan. Such a plan must describe in detail the company's plan to separately handle suitable and unsuitable overburden materials in order to isolate the unsuitable materials below the rooting zone.

More limited overburden data are available from those portions of the petition area not within the proposed Montco mine area. These include information on (1) 5 holes on the 1977 and 1978 EMRIA study sites on Otter Creek, (2) 2 additional holes drilled by Montco northeast of Ashland (Montco, 1980d, v. 23, table M-1; and unpublished data of Montco), and (3) 35 holes drilled in April 1981 throughout the petition area (excluding the Montco project area) as part of the DSL-OSM overburden sampling project. As with the Montco project area, there is a high degree of variability in the suitability of materials that exist in these other portions of the petition area.

Data from the overburden of five drill holes in the area north of Ashland and West of the Tongue River indicate that an average of about 20 feet of suitable and reasonably accessible material are available. In the area north of Ashland and east of the Tongue River, data form 16 drill holes indicate that suitable overburden materials averaging 65 feet thick are present.

In the Otter Creek drainage, data from the material associated with 14 drill holes suggest that an average of approximately 40 feet of suitable material occurs. The distribution of suitable and unsuitable material in Otter Creek appears to be somewhat clustered or nonrandom. However, the delineation of more definitive patterns in this distribution would require considerably more overburden sampling and characterization than is available to date.

Other available overburden information consists of data for six drill holes east of the Montco project area on the south side of the Tongue River. These data indicate that an average of 15 to 30 feet of unsuitable surface materials overlie about 20 feet of suitable overburden material in the area. The accessibility of such material for special handling would be of primary concern from a reclamation standpoint. By Montana laws and rules, a mining and reclamation plan would have to describe in detail the methods to be used to systematically identify and separately handle these materials. (See 82-4-231 and Montana ARM 26.4.506.)

No direct overburden information is available for that portion of the petition area between the west side of the Tongue River and south of the Northern Cheyenne Indian Reservation. However, there appears to be no reason to suspect that the characteristics of the materials here differ from those described earlier for all other portions of the petition area. Even so, the possibility that this may be the case cannot be wholly discounted. Thorough characterization by mining companies of overburden materials in this area would be required as part of any site-specific mining and reclamation plans pursuant to 82-4-222(1)(j), MCA, and Montana ARM 26.4.304(7).

In summary, all information available at this time indicates that, although highly saline and sodic soil and overburden materials occur in the petition area, significant volumes of suitable soil and overburden materials also occur. This contradicts the allegation that there are inadequate materials for revegetation. Whether, in specific areas, sufficient suitable soil and overburden are available in locations amenable for special handling for reclamation purposes can only be ascertained by intensive characterization of soils and overburden in such areas and by the evaluation of site-specific mining and reclamation plans in these areas.

Specific field sites referenced by the petitioners

Exhibit 9, page 6, paragraph 13 (Richard Opper's first affidavit), alleges:

> "Pervasive signs of salt seepage, poor soil structure, sparse vegetation, and sodium and salt indicator plants illustrate that soluble salts and sodium represent significant problems for the petition area."

Exhibit 9a, page 5, paragraph 17 (Richard Opper's second affidavit), alleges:

> "Evidence of salt and/or sodium affected soils was found throughout the petition area."

The first statement above is Mr. Opper's interpretative summary of field observations he made in September 1980. The observations are described in item 12 of his affidavit. The second statement is an excerpt which refers, in part, to his second set of field observations made in December 1980 and which are described in items 7 through 15 of the second affidavit.

Problem sites identified by Mr. Opper were evaluated by DSL and OSM. Some of them were sampled for analytical purposes. Following are DSL and OSM observations and responses to observations, interpretations, and statements made in the affidavits concerning these sites.

Opper's September 1980 sites.--Site No. 1 was described by Mr. Opper as having an "extremely sparse" vegetative cover and had a soil surface that was "extremely compacted," had "poor structure," and "was either currently or formerly influenced by sodium." The only feature obvious to State and Federal personnel who visited the site was a rock outcrop area with relatively little or no soil which would appear to account in large part for the sparse vegetative cover.

Site No. 2 included a Tongue River flood plain hayfield and an adjacent greasewood stand. Mr. Opper suggested that salts and sodium may have leached below the root zone in the hayfield because of irrigation, whereas this was allegedly not the case in the greasewood stand. He went on to say that "the haylands could not be used as an indicator of suitable recoverable topsoil because they do not represent the dominant soil conditions in the area."

The hayfield and greasewood stand were both sampled. Results did indeed show a lack of accumulated salts in the hayfield, because the electrical conductivi ties (EC's) were equal to or less than 1 mmho/cm and the SAR's were less than 1.5 to a depth of 5 feet. This could have been caused by leaching from irrigation water. In contrast, in the greasewood stand samples, EC's and SAR's were greater than 13 mmhos/cm and 21, respectively, below 22 inches. This latter area was mapped by the Soil Conservation Service as "yamac loam, alkali" and is previously described as saline and/or sodic, constituting 1.5 percent or less of the area underlain by strippable coal reserves in the petition area.

Sites Nos. 3 and 4 involved a deep alluvial soil which Mr. Opper described as soil "compacted at the surface" and in which "poor structural development that is usually the result of the influence of sodium" was reported.

Observations of DSL and OSM suggest that the "compaction at the surface" was caused by raindrop impact, sheet erosion, redeposition, drying of the soil and subsequent crusting of the surface (Baver and others, 1972). Samples of site No. 3 soils were taken for lab analysis which indicated low sodium levels (SAR's did not surpass 6.2 to a depth of 5 feet), although EC's reached 8.1 mmhos at a depth of 20 inches.

Mr. Opper made the same observations at sites Nos. 5 and 6 as he did at Nos. 3 and 4, but DSL and OSM personnel did not see nor were they able to verify his observations here. Site No. 7 was described by Mr. Opper as having salt crusts and adjacent salt seeps. Examination of this site by DSL and OSM did not reveal these conditions.

Opper's December 1980 sites.--It was not certain whether sites Nos. 1 and 2 on Hanging Woman Creek were found, since Mr. Opper's observations on the relative frequency of blue grama and big sage could not be substantiated. However, the occurrence of greasewood and a salt crust on the surface of a sandstone and clinker outcrop were seen. Greasewood was used as an indicator in mapping saline-sodic soils in Rosebud County (Lewis Daniels, Soil Conservation Service, Forsyth, Montana, oral commun., 1981). These soils have been discussed previously. Salt crusts on rock outcrop areas are not unexpected in southeastern Montana. They indicate the presence of soluble salts in the bedrock or soils that accumulate on surfaces where ground water discharges and evaporates, leaving the soluble salts behind.

Site No. 3 was seen and consisted of a salt crust on a steep (50 percent) slope where bedrock occurred on or near the surface. Site No. 6 was another area of salt precipitation on a hillside. The same responses as for sites Nos. 1 and 2 above apply in these two cases.

Site No. 4 appeared to be a salt crust along the Otter Creek drainage. Occurrence of salt here was probably the result of seasonal reductions in the level of Otter Creek and subsequent deposition of salts as water evaporated from the banks of the creek. Otter Creek at Ashland has been reported to have a total dissolved solids content which can approach 2,700 mg/L (U.S. Bureau of Land Management, 1975), which would likely account for the origin of the salts.

Site No. 5 was reported by Mr. Opper as a flood plain area on the Tongue River with an apparent very low vegetative productivity that may be partially the result of salts and sodium. He also indicated that salt crusts were visible on the hills to the west. DSL and OSM could not substantiate these observations. The site, which is dominated by western wheatgrass, does not appear to have a very low productivity, nor were any salt crusts observed on the hills to the west.

In summary, Mr. Opper's sites do not provide sufficient evidence that the petition area can be neither technologically nor economically reclaimed. Salt crusts on rock outcrops, on hillsides, or roadcuts are not evidence, in and of themselves, of the lack of sufficient suitable materials for reclamation. Other observations of Mr. Opper either were not substantiated or evoked alternative explanations. The greasewood-alkaline soil combinations, as previously discussed, comprise a very small percentage of the petition area and, thus, have little significance.

Smectite clays in soils

Page 8, paragraph 13, alleges:

> "Soils in the area appear to be dominated by smectite clays, which are highly sensitive to exchangeable sodium, thereby aggravating the adverse effects of an already serious sodium problem. Opper affidavit, Exhibit 9, paragraphs 10, 17."

In support of this allegation paragraph 10 of Mr. Opper's first affidavit (exhibit 9) is an explanation of how clay mineralogy interacts with sodium in affecting soil physical properties. He states that soils dominated by swelling clays should be considered sodic if the SAR's are about 8 to 10 or greater as compared to soils dominated by nonswelling clays where SAR values of 15 or greater would put them into the sodic category. He cites his own published work (Opper, 1979) in support of his statements.

In paragraph 17 of the same affidavit, Mr. Opper has interpreted some information in the Montco application on clay mineralogy of several surface soil samples by saying that "all samples contain appreciable amounts of smectite (swelling) clays," which would aggravate the adverse effects of sodium contained in the samples.

DSL and OSM agree with the basic principle put forth in paragraph 10 of Mr. Opper's affidavit. Other researchers in addition to Opper (1979) have made similar statements as to the enhancing effect of swelling clays on sodium-caused soil physical problems (Sandoval and Gould, 1978; U.S. Salinity Laboratory Staff, 1954).

With regard to Mr. Opper's interpretation of the Montco soil clay mineralogy data, the numbers in the list of minerals for the Montco samples (Montco, 1980d, v. 15, supplement E4) refer to the principal peak height of each mineral that is recorded as part of the X-ray diffraction procedure. Of those minerals reported to be found in the Montco samples, the clay mineral fraction would normally be largely confined to smectite, illite, kaolinite, and chlorite (Grim, 1968). If the above numbers for these clay minerals are taken at face value, smectite is the dominant in only one of the total of 12 samples. (Dominance is defined in this specific instance as being greater than 40 percent of the clay fraction, which definition is the equivalent of Mr. Opper's definition in paragraph 10 of exhibit 9.) The highest smectite content of the clay mineral reached in these samples was 44 percent. The other 11 samples ranged from 0 to 3 percent in smectite clays with the average of all samples being 21 percent. Thus, one cannot conclude from this analysis that smectite clays constitute a dominant factor (by Mr. Opper's definition of dominant) to be considered in these particular samples.

Further consideration of the Montco data suggests that a complicating factor was introduced into the analytical procedure, which may render <u>any</u> interpretation of these data tentative at best. Because quartz and feldspar are not normally significant components of the clay-size fraction (Baver and others, 1972; Grim, 1968), the consistent and apparently relatively abundant occurrence of quartz and feldspar in the mineralogical data reported for the samples in question suggests that the analysis was not conducted on the clay fraction only, but on each of the samples in bulk. Discussion with Montco confirms the apparent omission of a particle-size-separation step prior to analysis. The analysis should have been done on the clay fraction only or individual components of the clay fraction as has been conventionally recommended (McNeal and Sansoterra, 1964; Whittig, 1965). Analysis of bulk samples can create background "noise" in the X-ray procedure if significant quantities of nonclay minerals are present in the samples. This can complicate interpretations of clay mineralogical composition.

Other apparently more reliable data have been provided by Montco regarding an additional clay mineralogical analysis that was conducted on eight overburden samples taken from two drill holes at depths of as much as 120 feet below the surface (Montco, 1980d, v. N, table N-6). Most of these samples ranged from moderately fine to very fine textured, while SAR's ranged from 3.4 to 35.0. No smectite clays could be found in any of the samples.

Decker Coal Company submitted clay mineralogy data to DSL on overburden samples taken at the West Decker mine (E. Gary Robbins, February 4, written commun., 1976). This mine is located 15 to 20 miles southwest of the petition area. The data from analysis of samples from two drill holes indicated that smectite was dominant (defined as 50 percent or greater of the clay fraction) in 33 percent by volume of one drill hole and 78 percent in another.

From the same mine, three spoil samples were analyzed for clay minerals and the results indicated that the clays of two of the three samples were dominated (again, 50 percent or greater) by smectite (Dr. Murray Klages, Montana State University, written commun. to DSL, May 23, 1975). On the other hand, Doug Dollhopf and others (1981) have reported on further work at the West Decker mine showing a clay system in spoils on their test plot that is dominated by kaolinite (a nonswelling clay). Thus, the limited clay mineralogy data of a direct nature from both on (Montco data) and near the petition area do not support the allegation that the clay fraction of soil and overburden in the petition area is dominated by smectite (swelling clays). Considerably more clay mineralogy data from the petition area would certainly be desirable. An alternative approach for procuring clay mineralogy information is described below.

Since the soil physical properties and, thus, overburden suitability are a function of the sodium status of the material, texture, and clay mineralogy (Dollhopf and others, 1981), an indirect but comprehensive approach to include the clay mineralogy factor in the equation is to also examine the saturation percentage of the material in question. It is assumed that if the SAR and texture remain constant, the saturation percentage will increase as the percentage of swelling clays increases. The same direct relationship between saturation percentage and sodium and clay content should hold, everything else being equal. Dollhopf and others (1981) have recommended that when sodic materials exhibit saturation percentages that exceed 90 percent, such material should be excluded from use as root zone media because of the increased potential for deterioration of soil physical properties and upward salt migration.

Therefore, if saturation percentage is used as a criterion for evaluating soil or overburden suitability along with SAR, clay content, electrical conductivity, etc., the clay mineralogy factor will presumably have been taken into account. Saturation percentage was, in fact, used in the evaluation of overburden suitability as discussed earlier under "Overburden." The above recommendation of Dollhopf and others (1981) was used as a guideline.

In summary, existing direct and indirect information on clay mineralogy continues to support the contention that significant volumes of suitable overburden for reclamation purposes appear to exist in the areas for which data are available.

Shallow soils

Page 8, paragraph 13, alleges:

> "The data indicate further that well over 50 percent of the soils concerned are potentially too shallow for recovery. Opper affidavits, Exh. 9, paragraph 15; Exh. 9a, paragraph 18."

In support of this allegation, paragraph 18 (exhibit 9a) is cited:

> "I have reviewed published and unpublished U. S. Soil Conservation Service Soil Survey information on soils in Powder River and Rosebud Counties. Soil series which are less than 18 inches in depth are probably too shallow for use in reclamation. Soil associations comprised of one or more shallow series are potentially too shallow for recovery. It appears that well over 50 percent of the soils in the petition areas are potentially too shallow for recovery. Even if salt-free soils existed in the petition area, it is unlikely that they could be found in sufficient quantities for use in the burial of sodic/salty material. The available evidence indicates that lack of suitable topsoil would become a significant and possibly insurmountable obstacle to reclamation should surface mining occur within the petition area."

Evaluation of this allegation was initiated by summarizing the current information regarding Soil Conservation Service soil survey mapping units in the petition area, using WELUT's computer service in Fort Collins. A summary by acreage of all soil mapping units was thereby produced. All mapping units which were composed of more than 50 percent shallow soils were then selected. "Shallow" (consistent with the Soil Conservation Service definition) was used to characterize those soil series whose profiles were 20 inches deep or less. The abundance of coarse fragments in the profile was also incorporated into the definition of "shallow"; a profile with greater than 35 percent by volume of coarse fragments (U.S. Department of Agriculture, 1978) within 20 inches of the surface was also considered shallow.

A final factor entering the analysis was that, to the extent possible at this time, areas within the petition area identified by the USGS as having no strippable coal reserves were excluded from the analysis. The exclusion of such areas will, at a later date, be more specifically made a part of this analysis as information on the coal resources is placed into WELUT's computer system.

Evaluation of the shallow soils indicate that about 59 percent of the acreage in that portion of the petition area considered is dominated by shallow soils. However, DSL and OSM experience does not support the statement that soils less than 18 inches in depth and soil associations composed of one or more shallow series are potentially too shallow to salvage for reclamation. It is not unusual in Montana coal mines for equipment, such as scrapers and dozers, to have the capability of salvaging surface soils to a minimum depth of 6 inches. It is also well within the capability of such equipment to salvage pockets of suitable soil material in complexes or associations which also contain areas of unsuitable or no soil material. Such salvage efforts (to the practical limits of human and mechanical capability) are required by Montana ARM 26.4.701, which states that all available topsoil, including A, B, and C horizons, will be salvaged from the area of land to be disturbed.

If we thus consider only those mapping units dominated by soils with 6 inches or less of available soil material as being too shallow for recovery, we find that these mapping units make up 23 percent of the area under consideration. This finding does not support the allegation that well over 50 percent of the soils are too shallow for recovery.

Future outputs from WELUT's program will provide a more accurate calculation to address this allegation and will consider the acreage covered by soils too shallow for recovery, regardless of whether these soils occur in mapping units dominated by such soils or whether they occur as nondominant fractions of mapping units dominated by deeper soils. The reasoning for this, of course, is that deep soils, shallow soils, and rock outcrop areas with no soil occur together in highly variable patterns and proportions throughout the petition area.

Further consideration of the shallow soils indicates that a mining company could propose to use suitable overburden materials in place of or along with surface soil (Montana ARM 26.4.703). Such a proposal would require documentation by the company of problems with quality or quantity of existing surface soil. It would also require that the company adequately demonstrate (through analytical testing, greenhouse tests, field trials, etc.) that use of such material would be consistent with the basic reclamation and environmental protection performance standards of the Montana act and rules.

Keeping in mind the above considerations and current data, as well as the earlier discussion concerning the fact that significant volumes of suitable overburden could be identified in the petition area, the allegation that it is unlikely that sufficient quantities of salt-free soil or overburden materials needed for revegetation can be found in the petition area cannot be substantiated.

Effects of sodium and salts on vegetation

Page 8, paragraph 14, alleges:

> "Soluble salts inhibit plant growth and can prevent successful reclamation from being achieved. Opper affidavits, Exh. 9, paragraph 5."

Page 8, paragraph 15, alleges:

> "High exchangeable sodium concentrations in the soil and overburden would have adverse effects on both plant growth and soil structure. Poor soil structure results in low infiltration, low root penetration, poor gas exchange, and accelerated erosion. Opper affidavits, Exh. 9, paragraphs 5, 6, 8."

The concepts expressed in the above two paragraphs are generally accepted and are well documented in Mr. Opper's affidavit. The relationship of saline/sodic soil and overburden materials to the petition area has been addressed in detail in the responses to paragraph 13 of the petition. There does not appear to be a lack of suitable soil and overburden materials for revegetation.

Migration of salts after mining

Page 8, paragraph 16, alleges:

> "Mining activities would release salts from overburden strata and would further add to the saline and/or sodic conditions of the area. Additionally, upward migration of salts and sodium would be exacerbated by the activities of mining. Opper affidavit, Exh. 9, paragraph 10."

Page 9, paragraph 17, alleges:

> "Climatic characteristics of the area would further impede successful revegetation. Under the semi-arid (14 inches annual rainfall) conditions in the petition area, migration of salts and sodium would tend to be in an upward direction resulting in high concentrations of these materials in the root zone and on the soil surface. Opper affidavit, Exh. 9, paragraph 5."

That salts are released or made more available for dissolution by mining of overburden strata is well documented (Rowe and McWhorter, 1978; Van Voast and others, 1976). Overburden strata having salt or sodium levels of concern (as indicated by conventional saturated paste analysis) would require burial pursuant to Montana ARM 26.4.506. The question of the relationship of overburden salt and sodium levels on the petition area to reclaimability is discussed at length in the responses to the allegations in paragraph 13 of the petition. The relationships between saturated paste chemistry of overburden materials to salt loading of postmining ground waters have been investigated and reported on by Van Voast and others (1978) and Rowe and McWhorter (1978). Please see the preceding hydrology section for a discussion of potential saline-seep production.

Upward migration of sodium is a potential problem in mine reclamation in the northern Great Plains. This has been documented by investigators working primarily in North Dakota (Merrill and others, 1980; Sandoval and Gould, 1978). Mr. Opper has discussed this further in paragraph 13 of exhibit 9 in support of the petition.

Virtually the only comprehensive study in Montana regarding upward migrational sodium is that of Dollhopf and others (1981) at the West Decker mine. This research has included the study of (a) the movement of sodium, salts, and water in the spoil-soil root zone region and (b) the effectiveness of irrigation and soil amendments to ameliorate sodic spoil condition, should such treatments be deemed necessary. After 2 years of study, Dollhopf concluded:

1. "No upward migration of sodium salts from sodic spoils into topsoil was measured. Upward sodium movement from spoils into topsoil by diffusion or convective flow was either very small or leached back into spoils during spring precipitation. This result was true in all treatments including the check, in irrigated and nonirrigated plots.

2. "Topsoil salinity levels remained low (0.5 ± 0.5 mmhoms/cm) after 2 years, while spoil levels remained moderate (2.9 ± 1 mmhos/cm). Subsoil salinity levels fluctuated only ± 1 mmhos/cm * * *.

3. "Supplemental irrigation did not notably expedite the lowering of SAR levels in the spoil material * * * . All plots experienced a 5 to 15 unit decrease in SAR in the sodic subsoil zone.

4. "Since all chemical amendment treatments and the check resulted in 5 to 15 unit decreases in spoil SAR levels after 2 years, chemical amendments at the West Decker mine may not be beneficial. Additional years of monitoring will be required to substantiate this result.

5. "Measured decreases in spoil SAR levels were due, in part, to the leaching of Na, but largely due to increases in soluble Ca. This result was especially applicable in plots which received chemical amendments.

6. "The potential for upward salt migration in topsoiled sodic mine soils is largely a function of the soil texture and clay mineralogy."

Because the above reported results are based on only 2 years of data, it would be desirable to continue this study to determine if the initially observed trends continue over a several-year period. Decker Coal Company has indicated a willingness to support continued monitoring of this study area (E. Gary Robbins, Decker Coal Company, written commun. to DSL, February 11, 1980).

Soil texture, clay mineralogy, saturation percentage, and sodium levels of the overburden in the petition area have been discussed previously in the responses to the allegations in paragraph 13 of the petition. The recommendations of Dollhopf and others (1981) regarding maximum tolerable levels of certain of these key properties to avoid problems of topsoil sodication were generally utilized in the overall evaluation of overburden suitability. Thus, the conclusion that there does not appear to be a lack of suitable materials for revegetation in the petition area pertains here as well. That is, although existing information indicates that highly saline and sodic soil and overburden materials occur in the petition area, significant volumes of suitable soil and overburden materials also occur. This fact also fails to support the allegation that salinization and sodication of the postmining rooting zone and soil surface will automatically occur under the prevailing climatic conditions of the petition area. Whether, in specific areas, sufficient suitable soil and overburden are available in locations amenable for special handling can only be ascertained by intensive characterization of soils and overburden in such areas and by the evaluation of site-specific mining and reclamation plans.

Availability of salt-free soil materials

Page 9, paragraph 18, alleges:

> "The shortage of salt-free topsoil available to bury sodic/saline material presents a technological obstacle to successful reclamation. Even with sufficient suitable materials for burying sodic spoils, the necessity of hauling water, adding soil amendments and

> providing drainage to counter the sodium problems would be economically prohibitive * * *. Opper affidavit, Exh. 9, paragraphs 11, 15, 19."

The first statement in this allegation has been responded to in detail in the response to the allegations in paragraph 13 of the petition. The second statement appears to be self-contradictory, because if sufficient suitable materials are available for burying sodic spoils, it does not follow that a need exists for soil amendments and for providing drainage. The necessity and economics of hauling water are determined on site-specific operations in the permitting process.

<u>Translocation of salts</u>

Exhibit 9, paragraph 11 (Richard Opper's first affidavit), states:

> "By destroying overbuden strata, mining makes available more salts for translocation. Also, the loosening of the soil allows these salts to be more readily transported (Wiener, 1980). At the Decker Mine, Department of State Lands officials have already found evidence of salt translocation in reclaimed areas, graded spoils, and around ponds (Wiener, 1980), even though the effects of salt translocation often take decades to manifest themselves."

The general concepts contained in the first two sentences have been discussed in the immediately preceding allegation response to paragraphs 16 and 17 of the petition. See the hydrology section for further discussion of these issues.

Some visual evidence of salt translocation was found about 4 years ago at the West Decker mine, as pointed out in the affidavit. To more effectively monitor salt and sodium movement at the West Decker mine which may be deleterious to respread topsoiling material and to revegetative efforts, DSL and OSM recently required the company to set up such a monitoring program throughout the mine (State permit No. 81001, issued March 27, 1981). This will be continued for an indefinite number of years.

Salient features of the study of Dollhopf and others (1981) regarding sodium and salt movement at the West Decker mine were summarized earlier. The desire for continuing this study as well as the above-described monitoring program required of Decker Coal Company reflects the need for an examination of the long-term potential for salt translocation problems to make themselves evident. All the answers are far from being known. Some of these studies may aid in gaining more understanding of these potential problems.

Page 9, paragraph 19, alleges:

> "The effects of salt translocation often take decades to manifest themselves. Evidence indicates that burial of salty or sodic material by relatively non-saline topsoil may only postpone consequences. Opper affidavit, Exh. 9, paragraph 11. Surface mining and reclamation technology in the Northern Great Plains is too recently developed to lend the long term perspective necessary to assess the effects of burying sodic materials."

These allegations have been answered in the responses to paragraphs 16 and 17 of the petition and in the response to paragraph 11 of exhibit 9. There does not appear to be a back of suitable materials with which to mitigate this problem.

Erosion and reclamation failure

Page 9, paragraph 20, alleges:

> "The combination of poor soil structure and the lack of vegetative cover which would result if reclamation fails would increase the susceptibility of soils to wind and water erosion. Opper affidavit, Exh. 9, paragraph 8."

Revegetation failure would increase the probability of erosion problems on disturbed material. This would be true regardless of whether the cause of the failure was sodic or saline conditions of soil materials, soil textural problems, severe drought, or improper grazing management. If, as a result of the evaluation of a mining and reclamation plan submitted to DSL and OSM, it appeared unlikely that revegetation, in particular, or reclamation, in general, would not be accomplished consistent with the Montana act, a permit to mine could not be issued pursuant to Section 82-4-227, MCA.

Previous discussion on soil and overburden suitability, based on existing information (response to the allegations in paragraph 13 of the petition), does not lend adequate support to the contention that there are inadequate materials for revegetation. Therefore, there is not sufficient evidence to conclude that revegetation will fail due to inadequate soil material.

CHAPTER V.

ALTERNATIVE ACTIONS

This section provides descriptions and analyses of impacts of the five alternatives considered in this document.

Each alternative is described, followed by an analysis of the probable impacts of implementing that particular alternative. Impacts considered are portrayed by resource discipline in the following order: (1) Surface-water and ground-water systems; (2) vegetation and soils; and (3) coal resource, and supply and demand for coal. Impacts are identified as either short or long term. Each analysis also includes discussions of short-term versus long-term trade-offs and identifies any irreversible or irretrievable commitments of resources.

Where an alternative was considered but not analyzed, the reasons for dropping the alternative from further consideration are presented.

The following alternatives are analyzed to provide a basis on which decisions on the petition area can be made. Possible decisions include: (1) grant the petition, (2) reject the petition, (3) conditional designation, and (4) designate surface mining as unsuitable but allow underground mining. The conditional designation option includes designating types or methods of mining, as well as designating only specific portions of the petition area.

A. DESIGNATE THE ENTIRE PETITION AREA AS UNSUITABLE FOR ALL SURFACE COAL MINING OPERATIONS

Under this alternative, the Director (OSM) and the Commissioner (Montana DSL) would find that, on the basis of evaluations of the allegations of the petition and the recommendation of the Bureau of Land Management, either (1) that the mandatory criteria of Section 522(a)(2) or 522(e) of SMCRA and Section 82-4-228 of SUMRA have been met, or (2) that under the criteria of Section 522(a)(3) of SMCRA and Section 82-4-228 of SUMRA, other important resources and values in the petition area should preclude surface coal mining operations.

Implementation of this alternative would not allow any new surface coal mining operations within the petition area nor would it allow any new Federal coal leasing for surface mining operations unless such designation is terminated by petition. Extraction of about 3.484 billion tons of recoverable coal in the petition area for power generation or other uses would be precluded.

In consequence of this designation, there would be no impacts to resources from coal mining activity. Vegetation, soils, and surface- and ground-water systems would remain essentially in their present condition, provided that present land use and management patterns remained constant.

No Federal coal has been leased within the petition area. At least half of the petition area coal is privately owned; much of this fee coal has been leased. The State of Montana also owns coal in the area, some of which has been leased. Nine companies have surface or coal leases in the area that would be affected if the petition is granted.

Under this option, the Coal Creek mine would be precluded from expanding to areas not already permitted. Montco has a mine permit application pending with the State of Montana. This proposed 12-million-ton-per-year operation, between Ashland and Birney, Montana, would not be able to proceed if the petition were granted in its entirety. Also, the proposed Tongue River Railroad may be adversely affected; without additional active mines, the need for the railroad would be reduced, and construction could be delayed indefinitely.

Five tracts of Federal coal within the petition area are being considered for leasing in the 1982 Powder River lease sale. If the entire petition area were determined to be unsuitable, a maximum of 621 million tons of Federal coal would be removed from the 1982 Powder River Federal lease sale. In order to make up this 621-million-ton deficit, the Department of the Interior might lease additional coal from the Gillette and Highlight Review areas in Wyoming. Because the current leasing target set by the Department of the Interior already includes coal from these areas, such additional leasing could transfer major impacts not previously anticipated to that coal-producing region of Wyoming.

As stated in chapter IV, the national cost of meeting the 1995 coal demand under a limited leasing scenario could increase by just over $100 million (1978 constant dollars) if the petition area were removed from production.

National coal consumption should not (within the foreseeable future) be limited by supply constraints caused by designating the petition area as unsuitable for mining. The Department of Energy (1980) reported that the coal industry was then producing only 87.9 percent of the existing capacity. All the above impacts are long term, and there are no irreversible or irretrievable commitments. The possibility of terminating, by petition, such designation (based on development of new data, technology, or reclamation techniques), precludes the coal from being irreversibly lost.

B. DESIGNATE NONE OF THE PETITION AREA AS UNSUITABLE FOR SURFACE COAL MINING OPERATIONS

Under this alternative, the Regional Director (OSM) and the Commissioner (Montana DSL) would find insufficient cause to designate any of the petition area as unsuitable for surface coal mining operations. Selection of this alternative would not imply approval of surface coal mining operations within the petition area. Such approval or rejection can only be given after a mining company with a coal lease has submitted a mining and reclamation plan with site-specific data to the appropriate regulatory authority for review and approval for a permit to mine. In addition to the review of any such plan for compliance with the SMCRA and SUMRA, OSM and the DSL would also undertake an appropriate environmental review in compliance with the NEPA (National Environmental Policy Act) and the MEPA (Montana Environmental Policy Act). The review would consider comments and recommendations from the surface-managing State and Federal agencies, as well as comments from all segments of the public. Stipulations resolving any identified conflicts or adverse impacts could be added as conditions of mine plan permit approval.

The no designation alternative analyzed the maximum mining potential both within and upstream from the petition area based on currently estimated recoverable coal resources and current mining technology.

There is one 75,000-ton-per-year mine in the petition area--Coal Creek. In addition, Montco has filed an application with the DSL for a proposed mine on approximately 1,280 acres of State-leased lands and on approximately 8,920 acres of privately leased lands. This mine plan projects peak production of 12 million tons per year for a total of 186 million tons. The decision on this application is pending.

Under the no designation option, if all minable coal were recovered, there would be a slight irreversible, long-term reduction in infiltration and recharge due to the disturbance of up to 1,060 acres of clinker in the petition area. The resulting increase in surface runoff would probably not have an important effect on the surface-water system.

The water quality impacts of this alternative are variable, long term, and irreversible. The analyses thus far indicate that the shallow Tongue River Member aquifers directly affected by, or down-gradient from, mining would have the greatest increase in TDS due to mining. Waters in these aquifers, considered good for livestock use prior to mining, would be poor to unsuitable for livestock use after mining. The water supply that would be necessary to support the postmining land use would probably have to be obtaind from deeper sources, possibly below the Lebo Shale Member. (See discussion of water supplies in chapter II.) Completing wells into the deeper aquifers would be more expensive due to increased drilling pumping depth and increased difficulty of drilling through the spoil.

Alluvial ground waters were predicted to have the next greatest increase in TDS as a result of mining. The salinity hazard of the alluvial waters for irrigation use in both drainages would remain high or would be increased to a very high level after mining. The suitability of the alluvial waters for livestock use, considered good prior to mining, would be lowered to fair along Otter Creek after mining.

The preliminary projections for the Tongue River itself indicate mining would have the most influence on the river during period of low flow (August to September) or when water levels are reduced to minimum instream flow reservations for aquatic life. The evaluation of increased development (including maximum mining and increased irrigation) along the Tongue River projects the quality of water in the river would present a high to very high salinity hazard for irrigation during periods of low flow (August to September). The projected impacts are considered long term. Again, the projected values are worst-case, exceeding what will actually be experienced (because an excessive recoverable acreage was used for the first computer runs).

Subirrigated areas and areas irrigated with alluvial ground water will experience unknown decreases in productivity.

Increased municipal, industrial, and mining development upstream from the petition area would result in withdrawals of water and decreases in the quality of the Tongue River water that would flow through the petition area. The extent of these impacts and the extent to which they would influence water quality in the petition area has not been calculated.

Since, under this option, mining activity is possible, the most obvious long-term impacts to soils would be destruction of the soil profiles, loss of soil structure, alteration of pore space, compaction, reduced organic content, and reduction or loss of the viability of native plant propagules because of disturbance or burial in stockpiles.

Soils on reclaimed lands might be less resilient to disturbances than those on undisturbed native range sites; therefore, they could be more susceptible to improper management practices for some unknown period of time after mining and initial reclamation occur (Montana Department of State Lands, 1980b).

The existing vegetation in those areas underlain by coal and on lands needed for associated facilities would be destroyed by mining. Revegetation of disturbed areas to the standards required by SUMRA and SMCRA appears to be possible. However, the vegetative pattern and diversity would probably change for the long term. The technology for long-term reestablishment of certain shrubs and trees, such as ponderosa pine, which are important in the petition area is not, at present, entirely defined and would require detailed evaluation at the mine-plan stage.

Under this alternative there would be no present or future impacts on the coal resources, or on the supply and demand for coal, as mining and leasing are not prohibited in the area.

C. CONDITIONAL DESIGNATION OF UNSUITABILITY

Designate as unsuitable for all surface mining operations those parts of the petition area on which reclamation is not technologically and economically feasible.--Under this alternative, the Director (OSM) and the Commissioner (Montana DSL) would find that certain parts of the petition area are unsuitable for surface coal mining operations, on the basis of the criteria of Section 522(a)(2) of the SMCRA and Section 82-4-228 of SUMRA.

The SMCRA and SUMRA require the regulatory authority to declare an area unsuitable for all or certain types of surface coal mining activities if it finds that reclamation as required by SMCRA and SUMRA is not technologically and economically feasible (SMCRA, Section 522(a)(2) and SUMRA, Section 82-4-228(2)).

The impacts of this alternative could be similar to those discussed in alternative B, but would occur to a degree dictated by the level of mining in those areas not covered by the designation.

Areas which are not technologically and economically feasible to reclaim pursuant to SUMRA and SMCRA have not been identified due to the lack of highly detailed site-specific data, which is necessary.

Designate methods, types, or levels of mining operations that would protect the resources of the Tongue River from the effects of mining operations.--Under this alternative, the Director (OSM) and the Commissioner (Montana DSL) would find that certain methods, types, or levels of mining operations would affect the resources of the Tongue River. At present, no methods or types of mining have been identified. Further analysis, public comment, and additional data will be considered and discussed, as appropriate, in the final.

D. DESIGNATE THE ENTIRE PETITION AREA AS UNSUITABLE FOR SURFACE MINING, BUT ALLOW UNDERGROUND MINING

Under this alternative, the Director (OSM) and the Commissioner (Montana DSL) would find that the petition area is unsuitable for surface coal mining but might be suitable for underground mining. Available data indicate that no coal reserves in the petition area are known to be recoverable by underground methods. As stated in chapter IV, it is not technologically feasible to mine (using underground mining methods) the thick-bedded Knobloch seam, nor is it economically feasible to mine the Sawyer and other thin beds owing to market conditions, lack of transportation, and subsidence problems. Therefore, this alternative will not be further considered. Should additional data or information indicate that there is coal recoverable by underground mining, this alternative would be analyzed accordingly.

CHAPTER VI.

PUBLIC PARTICIPATION AND REVIEW

This document is being jointly prepared by DSL and OSM. Information was and is being gathered and analyzed by both agencies in order that the conclusions reached be as accurate as possible. Input was also provided by the Montana Bureau of Mines and Geology, the Bureau of Land Management, the U.S. Geological Survey, the U.S. Forest Service, and the U.S. Fish and Wildlife Service. Additional information was used from both intervention documents and supporting affidavits.

Public notice of acceptance of the complete petition was given in the Montana Administrative Register, the Federal Register, and local newspapers. Personal notice has been given by mailings to all identifiable persons or parties with ownership interest in the petition area. This document has been mailed to all parties who have expressed an interest in being retained on or added to the mailing list. Additional copies of the document are available on request from the Montana Department of State Lands at the address shown on the cover sheet.

Public hearings will not be adversary in nature but will be for the purpose of gathering information relating to this draft document. Hearings will be held on October 21 and 22, 1981, from 6 to 10 p.m., in the multipurpose room, Ashland School, Ashland, Montana. Notice of the hearings will be given in the Federal Register, the Billings Gazette, the Powder River Examiner, and the Forsyth Independent, as well as by certified mail to all parties on the mailing list. Details regarding the hearings will be provided in these public notices. All persons wishing to give oral testimony at the hearings are strongly encouraged to provide a written copy of their statements.

Intervention petitions will be accepted until 3 days prior to the hearings (that is, until October 18, 1981). Written comments on this draft document will be accepted at the Montana DSL address shown on the cover sheet until 5 p.m., October 30, 1981. All written comments submitted in person should be given to the DSL receptionist on the top floor of the U.S. Fish and Game building, 1625 11th Ave., Helena, Montana. OSM and DSL strongly urge that written comments be submitted as soon as possible.

The draft document will be available for public review at the following locations:

Montana Department of State Lands, 1625 11th Ave., Helena, Montana 59620.

Montana Department of State Lands, 1245 N. 29th Ave., Billings, Montana 59101.

Department of the Interior, Office of Surface Mining Reclamation and Enforcement, Branch of Environmental Analysis, 1951 Constitution Ave., N.W., Washington, D.C. 20240.

U.S. Forest Service, Ashland Ranger District, P. O. Box 297, Ashland, Montana 59003

U.S. Geological Survey, 1526 Cole Blvd., Golden, Colorado 80401.

Bureau of Land Management, P.O. Box 940, Miles City, Montana 59301.

Parmley Billings Public Library, 510 North Broadway, Billings, Montana 59101.

Montana State Library, State of Montana, 930 East Lyndale, Helena, Montana 59601.

Rosebud County Library, 201 North 9th Ave., Forsyth, Montana 59327.

Powder River County Library, Broadus, Montana 59317.

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CHAPTER VII.

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CHAPTER VIII.

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APPENDIX A.

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS FOR GROUND WATERS IN THE TONGUE RIVER ALLUVIUM

Specific Conductance And Sodium Adsorption Ratios For Ground Water In Tongue River Alluvium

Date sampled (number of samples)	Reach	TDS 180°C (calc. value)	Field EC (µmhos/cm)	Na	Ca	Mg	SAR ratio	Source of data
				(mg/L)				
Nov. 79	2	848	1,240	174	70	35	4.2	P-1 Montco Permit Application Table Bc11-1
Nov. 79	2	852	1,270	111	117	48	2.2	P-3 Montco Permit Application Table Bc11-1
Nov. 79	2	1,160	1,650(Lab)	183	120	57	3.4	P-5 Montco Permit Application Table Bc11-1
Nov. 79	2	700	1,050	117	61	56	2.6	P-12 Montco Permit Application Table Bc11-1
Nov. 79	2	1,780	2,170	580	48	39	15.1	P-13 Montco Permit Application Talbe Bc11-1
Nov. 79	2	1,123	1,640	158	101	102	2.7	P-16 Montco Permit Application Table Bc11-1
Apr-May 80	2	1,910	2,485	450	107	61	8.6	P-10 Montco Permit Application Table Bc11-4
Nov. 79	2	794	1,150	55	126	56	1.0	Nance Alluvial Well Montco Permit Application Table Bc11-4
Nov. 79	2	1,010	1,370	422	4	<1	47.5	Knobloch Alluvial Well Montco Permit Application Table Bc11-2
Oct. 79	2	628	1,020	81	70	56	1.7	Elk Shoulder Well Montco Permit Application Table Bc11-2
Oct. 79	2	790	1,090	131	81	42	2.9	Shirley Parker Montco Permit Application Table Bc11-3
Oct. 79	2	774	1,090	97	95	52	2.0	Joe Sandciane Montco Permit Application Table Bc11-3
Oct. 79	2	758	1,050	126	93	45	2.7	Michael Bryant Montco Permit Application Table Bc11-3
Oct. 77	3	(1,915) 2,186	2,200	486	70	51	3.0	TRW7 Woessner et al., 1980 Montco Permit Application Table Bc11-3
1976-7 (5)	3	(547) 560	914(Lab)	115	30	38	0.5	10B p.521 and p.516
1976-7 (9)	2	(968) 991	1,429(Lab)	210	57	36	1.0	12A p.422
1976-7 (8)	2	(1,841) 1,881	2,917(Lab)	427	83	74	1.4	12B p.427
1976-7 (7)	2	(1,039) 916	1,579(Lab)	243	63	39	1.2	16B p.446
?	2		1,892				6.2	04544E05AAAC Van Voast 1981
?	1		1,363				2.7	07541E22ADCA Van Voast 1981
?	1		1,077				1.0	07542E06BCDB Van Voast 1981
?	3		1,200				-	03544E03D Hopkins

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS FOR GROUND WATERS IN TONGUE RIVER ALLUVIUM

Date sampled (number of samples)	Reach	TDS 180°C (calc. value)	Field EC (μmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of data
?	2		1,450				-	03544E15DA Hopkins
Sep. 79	1	(1,080)	1,600	140	64	100	2.5	06542E31DBBD USGS, 1981
Sep. 79	1	(1,140)	1,620	150	69	100	2.7	06542E31DBBA USGS, 1981
June 74	1	(705)	1,060	54	110	56	1.0	07542E06BCDB USGS, 1981
Apr-May 80	2	1,100	1,610	221	151	19	-	P-5 Montco Permit Application Table Bc11-4
Apr-May 80	2	730	1,120	118	61	62	-	P-12 Montco Permit Application Table Bc11-4
Apr-May 80	2	1,540	2,355	600	15	10	-	P-13 Montco Permit Application Table Bc11-4
Apr-May 80	2	1,180	1,550	159	82	98	-	P-16R Montco Permit Application Table Bc11-4
Nov. 79	2	1,120	1,620	247	82	52	-	WA-4 Montco Permit Application Table Bc11-1
Apr-May 80	2	1,090	1,630	240	89	60	-	WA-4 Montco Permit Application Table Bc11-4

SUMMARY (MEAN VALUES), BY REACH

1. N=5 1344 ± 242

2. N=24 1559 ± 488

3. N=3 1438 ± 551

APPENDIX B.

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS FOR GROUND WATERS IN THE TONGUE RIVER MEMBER, FORT UNION FORMATION

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR GROUND WATERS IN TONGUE RIVER MEMBER-FORT UNION FORMATION

Well No. (this report)	Date sampled (number of samples)	Reach	Formation Completed in	TDS 180°C (calc. value)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data Hole #
	1976-7 (9)	2		(1,507) 1,552	2,526(Lab)	567	16.	9.	28	11A Woessner et al. 1980 p.434
	1976-7	2		(2,255) 2,332	3,609(Lab)	824	13.	10.	18	11B p.439
	1976-7	2		(3,024) 3,012	3,871(Lab)	691	116	99	15	32 p.452
	1976-7	2		(1,382) 1,404	2,076(Lab)	462	6.	30.	17	29A p.479
	1976-7	2		(1,371) 1,356	2,233(Lab)	478	14.	10.	24	8A p.465
	1976-7	2		(3,408) 3,440	4,440(Lab)	1,126	28	14	38	27 p.502
	1976-7	2		(1,851) 1,831	3,234(Lab)	389	147	54	7	21A p.525
	1976-7	2		(774) 760	1,519(Lab)	182	101	47	4	30A p.460
	Nov. 79	2		1,890	2,590	768	5	3	67	IB-1 Montco Application Table Bc11-1
	Nov. 79	2		2,910	3,540	932	57	35	24	MK-2 Montco Application Table Bc11-1
	Nov. 79	2		1,070	1,660	444	3	<1	57	N-1 Montco Application Table Bc11-1
	Apr-May 80	2		1,740	2,330	689	5	3	60	N-2 Montco Application Table Bc11-4
	Apr-May 80	2		1,800	2,630	773	4	2	79	WN-2 Montco Application Table 8c11-4
	Apr-May 80	2		4,260	4,905	1,210	94	62	24	WN-15 Montco Application Table 8c11-4
	Apr-May 80	2		1,810	2,580	730	6	2	66	IB-1 Montco Application Table Bc11-4
	Apr-May 80	2		2,200	3,055	468	124	129	7	MK-5 Montco Application Table 8c11-4
	Apr-May 80	2		3,020	3,975	1,040	16	8	53	MK-10 Montco Application Table 8c11-4
	Apr-May 80	2		4,800	4,550	962	239	231	11	K-11 Montco Application Table Bc11-4
	Apr-May 80	2		3,990	4,265	1,160	22	12	49	K-12 Montco Application Table Bc11-4
	Apr-May 80	2		6,150	7,895	1,970	65	28	52	WK-5 Montco Application Table Bc11-4
	Apr-May 80	2		1,610	2,625	660	6	<1	66	WL-2 Montco Application Table 8c11-4
	Apr-May 80	2		1,400	1,665	496	8	2	41	WM-5 Montco Application Table 8c11-4

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR GROUND WATERS IN TONGUE RIVER MEMBER-FORT UNION FORMATION

Well No. (this report)	Date sampled (number of samples)	Reach	Formation Completed in	TDS 180°C (calc. value)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data Hole #
	Apr-May 80	2		3,000	3,875	1,050	11	5	66	WM-7 Montco Application Table Bc11-4
	Apr-May 80	2		1,210	1,805	490	6	1	49	WM-9 Montco Application Table Bc11-4
	Apr-May 80	2		5,140	4,670	846	273	9	9	MLV-1 Montco Application Table Bc11-4
	Apr-May 80	2		2,640	2,680	337	118	189	5	WN-9 Montco Application Table Bc11-4
	Apr-May 80	2			2,480	290	121	135	4	WN-12 Montco Application Table Bc11-4
	Apr-May 80	2			1,565	546	3	<1	70	WN-13 Montco Application Table Bc11-4
	Nov. 79	2		6,110	6,800	1,880	68	37	46	WK-5 Montco Application Table Bc11-1
	Nov. 79	2		1,590	2,270	673	6	2	61	WL-2 Montco Application Table Bc11-1
	Nov. 79	2		1,100	1,700	420	5	0	52	WM-5 Montco Application Table Bc11-1
	Nov. 79	2		2,460	3,360	889	8	4	64	WM-7 Montco Application Table Bc11-1
	Nov. 79	2		1,800	2,430	771	5	2	68	N-2 Montco Application Table Bc11-1
	Nov. 79	2		2,040	2,755	741	28	32	23	NN-2 Montco Application Table Bc11-1
	Nov. 79	2		3,990	4,720	1,200	75	37	28	WN-15 Montco Application Table Bc11-1
	Nov. 79	2		2,100	3,040(Lab)	473	140	123	+	MK-5 Montco Application Table Bc11-1
1	May 1975	Otter	TGRV	(508)	930	210	2.5	0.2	34	USGS, 1981 05545E35BABA
5	June 1975	Otter	TGRV	(1,430)	2,300	510	10.	2.6	37	05545E11CDCD
8	Nov. 1976	Otter	TGRV	(1,110)	1,630	390	3.2	1.6	44	05545E03ABCD
16	May 1976	Otter	TGRV	(596)	890	240	4.2	0.4	30	04545E27ACCD
17	Dec. 1973	Otter	TGRV	(900)	988	240	2.6	1.1	32	04545E27DBBA2
18	Jan. 1974	Otter	TGRV	(943)	1,009	255	2.3	1.0	35	04545E23CCCB
19	Jan. 1974	Otter	TGRV	(1,357)	1,520	381	3.1	1.3	46	04545E22ADCC
26	Nov. 1976	Otter	TGRV	(1,860)	2,470	330	110	113	5	04545E02CDDB
27	May 1976	Otter	TGRV	(1,250)	1,930	520	6.9	5.1	37	04545E02DACD
29	Dec. 1974	Otter	TGRV	(1,520)	2,375	530	23	12	22	04545E02BDDD
30	May 1975	Otter	TGRV	(1,880)	2,900	660	20	11	29	04545E02BDDD
31	May 1976	Otter	TGRV	(2,100)	3,180	720	25	9	31	04545E02BDDD
33	May 1975	Otter	TGRV	(3,510)	6,000	1,100	49	36	29	03545E34DDDA
34	May 1976	Otter	TGRV	(4,280)	5,200	1,000	170	200	12	03545E34DDDA

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR GROUND WATERS IN TONGUE RIVER MEMBER-FORT UNION FORMATION

Well No. (this report)	Date sampled (number of samples)	Reach	Formation Completed in	TDS 180°C (calc. value)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data Hole #
35	May 1975	Otter	TGRV	(5,280)	5,600	1,600	96	54	32	03545E34CACD
36	June 1976	Otter	TGRV	(5,720)	6,730	1,700	94	39	37	03545E34CACD
37	May 1975	Otter	TGRV	(1,960)	2,970	600	54	26	17	03545E34DABA
38	May 1976	Otter	TGRV	(2,570)	3,630	900	17	26	47	03545E34DABA
40	May 1975	Otter	TGRV	(4,090)	5,600	970	170	220	21	03546E30CCC
41	May 1976	Otter	TGRV	---	5,600	---	---	---	--	03545E34AACD
42	May 1975	Otter	TGRV	(3,050)	5,200	410	240	270	4	03545E26DBCB
43	May 1976	Otter	TGRV	---	4,170	---	---	---	--	03545E26DBCB
44	March 1975	Otter	TGRV	(3,640)	4,600	1,100	97	34	24	03545E26ADAC
45	May 1976	Otter	TGRV	(3,620)	4,840	1,100	96	34	24	03545E26ADAC
46	Dec. 1973	Otter	TGRV	(731)	1,400	300	2.8	1	39	03545E23DADA
48	May 1975	Otter	TGRV	(2,700)	3,700	550	78	180	8	03545E24ACDA
50	Jan. 1974	Otter	TGRV	(4,724)	4,944	727.5	141	336	8	03546E19BBAB
51	Jan. 1974	Otter	TGRV	(1,480)	2,400	370	88	160	6	03545E22BAAB
53	Jan. 1974	Otter	TGRV	(2,550)	4,000	830	42	25	25	03545E13DCBC
54	Dec. 1973	Otter	TGRV	(1,360)	2,400	470	11	3	32	03545E15DDDA
55	Apr. 1976	Otter	TGRV	(1,150)	1,650	260	58	58	6	03545E14CCAB
61	Feb. 1976	Otter	TGRV	(1,330)	1,790	230	78	100	4	03545E12BDCB
63	Oct. 1974	Otter	TGRV	(1,460)	1,500	370	57	67	8	03545E10BACD
64	June 1980	Otter	TGRV	(1,280)	---	150	61	80	8	03545E10BACD
67	May 1975	Otter	TGRV	(3,550)	4,600	900	100	110	15	03545E03BADD
68	Aug. 1974	Otter	TGRV	(1,790)	7,300	330	84	140	5	03545E01ABDD
74	Aug. 1974	Otter	TGRV	(1,320)	1,960	510	9.5	15	24	02545E36ACBA
86	Sept. 1972	3	TGRV	(1,970)	2,550	430	110	93	7	01545E01CABB
88	June 1975	Otter	TGRV	(915)	1,490	390	2.1	.9	57	05545E27BDDB
89	June 1974	Otter	TGRV	(1,100)	1,950	460	4	1.6	49	05545E28BBBA
90	Jan. 1974	Otter	TGRV	(2,800)	2,884	122.5	160	351	1	05545E18ADBA
91	Jan. 1973	Otter	TGRV	(2,530)	2,570	120	160	350	1	USGS, 1981 05545E18AACD
92	Jan. 1974	Otter	TGRV	(1,712)	1,792	330	51	66	7	05545E08BDDD
93	Jan. 1974	Otter	TGRV	(1,461)	1,573	378	133	141	1	05545E06DAAD
94	Jan. 1974	Otter	TGRV	(606)	960	250	2.4	1.5	31	05545E04BBDD
95	Jan. 1974	Otter	TGRV	(2,500)	2,602	1,775	163	245	2	04545E32CADC
96	Jan. 1974	Otter	TGRV	(1,661)	1,791	94.7	113	161	1	04545E30DDBB
97	Nov. 1977	Otter	TGRV	(1,340)	1,980	550	7.1	2.6	45	04545E28BDDC
98	June 1975	Otter	TGRV	(3,070)	4,100	640	180	140	9	04545E28ADDA
99	June 1975	Otter	TGRV	(2,480)	3,850	1,000	9.1	6.3	62	04545E19DADC
100	June 1976	Otter	TGRV	(3,520)	4,650	1,200	21	9.7	54	04545E19DADC
101	Dec. 1973	Otter	TGRV	(1,540)	2,600	320	91	160	5	04545E20CCAD
102	Jan. 1974	Otter	TGRV	(4,660)	5,100	670	240	420	6	04544E24ABBB
103	Jan. 1974	Otter	TGRV	(5,261)	5,040	670	238	424	6	04544E24ABBB

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR GROUND WATERS IN TONGUE RIVER MEMBER-FORT UNION FORMATION

Well No. (this report)	Date sampled (number of samples)	Reach	Formation Completed in	TDS 180°C (calc. value)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data Hole #
104	Aug. 1979	Otter	TGRV	(755)	1,280	320	1.7	.2	46	04544E08ACDD
105	Jan. 1974	Otter	TGRV	(668)	3,000	270	30	.6	74	04545E04DBCA
106	Nov. 1977	Otter	TGRV	(914)	1,465	370	2.1	.8	55	04545EDBDB
107	June 1975	Otter	TGRV	(1,300)	1,800	290	56	68	6	04544E05AAAC
108	Aug. 1975	Otter	TGRV	(3,480)	4,400	740	91	190	10	03545E310CDA
109	Feb. 1976	Otter	TGRV	(842)	1,390	350	.8	1.5	53	03545E32DDAC
110	June 1976	Otter	TGRV	(851)	1,410	360	3.1	.8	47	03545E32DDAC
111	Dec. 1973	Otter	TGRV	(1,267)	1,471	360	2.6	.9	50	03545E33CBDA
113	June 1975	Otter	TGRV	(792)	1,250	330	2.2	.4	54	03544E33BDAA
114	Aug. 1975	Otter	TGRV	(834)	1,600	350	2.4	.4	55	03545E19DDBC
115	Dec. 1973	Otter	TGRV	(837)	1,600	350	2.5	1.4	44	03545E19DDBD
116	Dec. 1973	Otter	TGRV	(1,130)	1,900	190	77	70	4	03545E22BBBA
117	Sept. 1979	Otter	TGRV	(307)	500	22	34	27	1	03544E128DDA
118	June 1980	Otter	TGRV	(323)	---	22	36	28	1	03544E12BDDA
119	April 1975	Otter	TGRV	(967)	1,580	400	3.6	.3	54	03544E11BCAB
120	May 1975	Otter	TGRV	(944)	1,550	390	2.6	.9	53	03544E11BCAB
121	April 1976	Otter	TGRV	(981)	1,530	410	2.8	.8	56	03544E11BCAB
122	May 1975	3	TGRV	(1,100)	1,650	220	63	68	5	03545E05DBBC
123	Sept. 1979	3	TGRV	(1,820)	2,630	460	52	67	10	03545E05DBAA
124	June 1980	3	TGRV	(1,790)	---	460	59	67	10	03545E05DBAA
125	April 1980	3	TGRV	(1,550)	---	250	95	120	4	03545E06AAAD
126	Sept. 1979	3	TGRV	(1,800)	2,630	480	60	48	11	02545E32DABD
127	Sept. 1979	3	TGRV	(1,720)	2,620	430	72	68	9	02545E32BBBB
128	April 1976	3	TGRV	(1,290)	1,820	160	140	110	3	02545E17CBBD
129	Sept. 1972	3	TGRV	(686)	1,020	78	61	73	2	02544E14CB
130	Sept. 1972	3	TGRV	(821)	1,190	180	45	47	5	02544E12BCCA
131	Sept. 1973	3	TGRV	(1,670)	1,780	200	130	140	24	01544E08DCAD
132	Sept. 1973	3	TGRV	(1,460)	2,000	420	14.4	5.9	3	01544E10CDBC
133	Sept. 1973	3	TGRV	(2,290)	2,800	440	110	130	7	01N44E34DBCD
134	Sept. 1973	4	TGRV	(978)	1,800	360	3.2	.6	48	01N44E31AABA
135	Sept. 1973	4	TGRV	(4,330)	5,000	430	220	450	4	01N44E30BDCA
136	Sept. 1973	4	TGRV	(1,250)	2,400	530	3	.6	73	01N44E27C8AC
137	Sept. 1973	4	TGRV	(4,478)	4,400	427.5	224	449	4	01N44E30BCDA
138	Sept. 1973	4	TGRV	(1,510)	2,300	210	110	98	4	01N44E29ACBD
139	March 1974	1	TGRV	(1,510)	2,100	650	1.6	1	99	06542E27ABBC
140	March 1974	1	TGRV	(910)	1,320	390	1.7	.4	70	06542E23CAB
141	March 1974	1	TGRV	(1,260)	1,810	540	2.	.6	86	06542E238CAC
142	March 1974	1	TGRV	(1,270)	1,800	540	2.6	.3	85	06542EBCAC
143	March 1974	1	TGRV	(1,270)	1,800	540	2.6	.3	85	06542E23BDBA
144	March 1974	1	TGRV	(1,230)	1,790	510	1.5	.4	96	06542E14DCAD

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR GROUND WATERS IN TONGUE RIVER MEMBER-FORT UNION FORMATION

Well No. (this report)	Date sampled (number of samples)	Reach	Formation Completed in	TDS 180°C (calc. value)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data Hole #
145	March 1974	1	TGRV	(1,220)	1,800	510	1.4	.2	107	06542E130BCC
146	March 1974	1	TGRV	(1,200)	1,790	510	2.6	2.3	56	06542E13BABD
147	March 1974	2	TGRV	(990)	1,430	430	2.2	.2	74	06543E18BABC
148	March 1974	2	TGRV	(1,230)	1,430	530	2.8	.6	75	06543E07DCCA
149	June 1975	2	TGRV	(1,370)	2,150	500	2.7	2.6	52	06542E01DDCC
150	June 1975	2	TGRV	(525)	819	42	69	49	1	06542EDDCC2
151	Aug. 1979	2	TGRV	(588)	1,050	230	1.7	.4	41	05542EADDA
152	March 1974	2	TGRV	(600)	990	240	2.2	.1	43	05542EDBBC
154	June 1975	1	TGRV	(567)	905	59	56	54	1.3	07542E06BCAA
155	March 1974	1	TGRV	(1,500)	2,100	650	4.	.4	83	06542E32CBA
156	March 1974	1	TGRV	(852)	1,300	360	2.2	.1	64	06542E32ABA
157	Oct. 1978	1	TGRV	(983)	1,400	380	.7	.1	113	06541E25CDAC
158	Nov. 1976	1	TGRV	(498)	750	44	59	50	44	06541E25CBDD
159	March 1974	1	TGRV	(1,180)	1,710	510	1.4	.6	91	06542E29CAAA
160	Oct. 1979	1	TGRV	(895)	2,100	520	2.6	1.3	66	06542E19CDBC
161	Nov. 1976	1	TGRV	(1,400)	1,700	260	78	100	5	06542E16ACDA
162	March 1974	2	TGRV	(221)	460	17	28	22	1	05542E31CCCD
163	March 1974	2	TGRV	(319)	520	21	36	39	1	05541E36CBBA
164	March 1974	2	TGRV	(162)	275	27	16	4.8	2	05542E21DBAB
165	March 1974	2	TGRV	(1,480)	2,700	550	4.6	.3	67	05542E20ADDB
166	March 1974	2	TGRV	(1,230)	1,900	170	82	110	3	05542E18DCDB
167	March 1974	2	TGRV	(820)	1,230	130	61	67	3	05542E16DDBD

Summary (Mean Values), By Reach

1 n=16 1,635 ± 387

2 n=53 2,741 ± 1,550

3 n=11 2,062 ± 595

4 n=5 3,180 ± 1,272

Otter Creek n=63 2,722 ± 1,531

Footnotes = (Lab), Laboratory

APPENDIX C.

BUREAU OF LAND MANAGEMENT ANALYSIS OF POTENTIAL COAL RESERVE TRACKS IN THE OTTER CREEK AND TONGUE RIVER DRAINAGES (26,675 ACRES)

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
222 North 32nd Street
P.O. Box 30157
Billings, Montana 59107

IN REPLY REFER TO:
3461.5 (932)
Tongue River

MAR 2 0 1981

Memorandum

To: Donald Crane, Regional Director, Office of Surface Mining, Brook Towers, 1020 15th Street, Denver, Colorado 80202

From: State Director

Subject: BLM Response to the Coal Unsuitability Petition Filed by Northern Plains Resource Council, et al.

The following comments represent my recommendations in accordance with Article B, I82 of the BLM/OSM/GS Memorandum of Understanding regarding the processing of petitions to designate areas unsuitable for surface mining. The petition was filed by Northern Plains Resource Council, et al. on December 29, 1980, and found to be complete by your office on January 19, 1981. The petition includes lands in Powder River and Rosebud Counties, Montana.

Federal lands within the petition area fall into two categories:

(1) Lands in the Ashland and Otter Creek coal fields which have been found "acceptable for further consideration for coal leasing", certain of which are currently under consideration for leasing in the Powder River Coal Activity Plan scheduled for completion in early 1982.

(2) The remaining federal lands which are not, at this time, under consideration for leasing.

My recommendations address these categories separately.

<u>Ashland and Otter Creek Coal Fields (Federal Land)</u>

The specific portions of these coal fields found to be acceptable for further consideration for coal leasing are currently under consideration for leasing in the Powder River Coal Activity Plan. Lease sales are scheduled to begin in April 1982. These coal fields were recommended for leasing in the Decker-Birney and Coalwood land use plans completed in 1974 and 1975. In 1979, they were subjected to the Federal Lands Review process, wherein BLM's unsuitability criteria (43 CFR 3461) were applied.

My recommendations regarding the specific allegations of the petition in these areas are enclosed, and are summarized below.

The petitioners allege that reclamation is not technologically or economically feasible because of soils conditions in the area and that surface coal mining will result in degradation of water quality in the Tongue River.

1. No areas should be designated unsuitable for surface mining due to soil conditions. Our analysis demonstrates that the soil conditions in the Ashland and Otter Creek coal areas are adequate for satisfactory reclamation. In fact, with the careful selection and placement of soils and overburden, the soils can be reconstructed so that they would be more useful and productive than prior to mining.

2. No areas should be designated unsuitable for surface mining due to the potential degradation of the water quality in the Tongue River. We examined the impacts of mining on the water quality in the shallow bedrock aquifers, the alluvial aquifers and the Tongue River. Our analysis determined that there will be localized downgradient impacts during and after mining to the aquifer systems. Some existing wells may have to be replaced after mining. The change in water quality would make it less desirable for domestic use but would not preclude continued use for livestock. Water is available in deeper aquifers to continue present uses.

   The increase in dissolved solids concentration in the Tongue River due to mining in the areas was estimated to be four percent under the worst case. This change is not significant to irrigation uses of water from the river.

<u>Remaining Federal Lands</u>

The remaining federal lands were also covered by the land use plans completed in 1974 and 1975. Due to a lack of coal data and multiple use tradeoffs, they were not recommended for coal leasing at that time. They cannot be leased until a comprehensive land use plan is completed and leasing is compatible with the decision in the plan, including the completion of the Federal Lands Review process.

At present, we have initiated the scoping process for a Resource Management Plan (RMP), scheduled for completion in 1984. All of these federal lands will be included. The RMP will include the identification of high and moderate potential coal resources, the application of the Federal Lands Review process and multiple use tradeoffs. The RMP will also include an EIS covering the multiple use tradeoffs and alternatives.

The purpose of the scoping process is to identify the issues to be addressed in the plan. The issues raised in the petition will be analyzed in the RMP. The petitioners have the opportunity to continue their involvement throughout the planning process and a protest period is provided upon completion of the plan.

It is my recommendation that these lands should not be designated unauitable for surface coal mining at this time. Delaying a decision on a deaignation until completion of the Resource Management Plan would not represent any jeopsrdy to the petitioner's interest. No federal coal leasing can be undertaken in these areas until the RMP and coal activity planning steps are completed. This is consistent with Section 522(s)(5) of SMCRA which states, "Determination of unsuitability of land for surfsce cosl mining . . . shall be integrated as closely as possible with present and future land use planning and regulstion processes at the Federsl, State and local levels."

ACTING

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1. Introduction

A. Background

The Northern Plains Resource Council (NPRC), et al., filed a petition with the Office of Surface Mining (OSM) and the Montana Department of State Lands (DSL) to designate certain lands in the Tongue River drainage unsuitable for surface coal mining. The petition was filed on December 29, 1980, in accordance with procedures outlined in the Surface Mining Control and Reclamation Act (SMCRA). The petition was determined to be complete on January 19, 1981. OSM requested that BLM make recommendations for the lands under its administration by letter on February 6, 1981, in accordance with Article B, IB2 of the BLM/OSM/GS Memorandum of Understanding for the Management of Federal Coal.

The petitioners allege that reclamation is not technologically or economically feasible because of soil conditions in the area and that surface coal mining will result in degradation of water quality in the Tongue River. The following analysis of these allegations and BLM's recommendation are limited to the Ashland and Otter Creek coal fields for the reasons stated in the transmittal letter.

B. Coal Information

A description of the Ashland and Otter Creek coal fields follows (figure 1). It is taken in part from Montana Bureau of Mines and Geology Bulletin 91, December 1973 and the Coalwood and Decker-Birney Management Framework Plan summaries.

Otter Creek Coal Deposit

The Otter Creek Coal Deposit is located in T.4 and 5S, R.45 and 46E, Powder River and Rosebud Counties and is about 12 miles south of Ashland by road. The deposit is limited on the west, south and east by excessive overburden and on the north it adjoins the Ashland coal deposit. The Otter Creek deposit is wholly within BLM's Decker-Birney Planning Unit.

The Knobloch coal bed contains the only strippable reserves in the Otter Creek coal deposit. Other coal beds include the King bed, which is 70 to 160 feet above the Knobloch bed in T.5S, R.45E and several higher beds, which are exposed along the steep slopes of the ridges on both sides of Otter Creek.

The Knobloch bed is thickest in the north, thinning gradually to the south. The Knobloch splits in the southern portion of the deposit.

The strippable reserves in the Otter Creek deposit follow:

Strippable Bed	Thickness (Feet)	Reserves (MM Tons)	Total (Acreage)
Knobloch	21-72	1,630	31,900

Ashland Coal Deposit

The Ashland deposit is in T.2, 3 and 4S, R.44 and 45E, Powder River and Rosebud Counties. The area is bounded on the west by the Tongue River and on the east by excessively thick overburden. The Beaver Creek-Liscom Creek coal deposit lies to the north and the Otter Creek deposit to the south. The Ashland coal deposit is located in both the Coalwood (Cw) and Decker-Birney (D-B) planning units.

The Ashland-Coalwood deposit contains both the Knobloch and Sawyer coal beds. The Knobloch is the more important bed, averaging 50 feet in thickness. The Sawyer coal bed lies above the Knobloch and averages 10 feet in thickness.

The Ashland Decker-Birney deposit contains the Knobloch coal bed. In this area, the Knobloch ranges in thickness between 50-60 feet. Other beds in the deposit are not economic.

The strippable reserves in the Ashland coal deposits follow:

Deposit	Strippable Bed	Thickness (Feet)	Reserves (MM Tons)	Total (Acres)
Ashland (Cw)	Sawyer	10	29.36	1,664
	Knobloch	50	715.88	8,089
Ashland (D-B)	Knobloch	50-60	788.00	8,000

The entire petition area, including the Ashland and Otter Creek coal deposits, are included in the Powder River Basin Known Recoverable Coal Resource Area (KRCRA).

There are no existing federal coal leases or Preference Right Lease applications in the petition area.

2. Summary of Planning Decisions

A. Management Framework Plan Decisions (MFPs)

It is the BLM's responsibility to develop comprehensive land use plans which result in resource and land use allocations for the public's lands and resources. Under the concept of multiple use management, all potential uses of the public's lands and resources are equally considered and evaluated before an MFP is developed and implemented.

Following is a summary of the MFP decisions regarding the federally managed coal resources in the Ashland and Otter Creek areas.

I. Coalwood Planning Unit - (MFP)

The Coalwood MFP was completed in 1975 by the Miles City District Office.

The coal resource allocation decisions recommended leasing in the least conflict areas of the Ashland coal deposit with the provision that mining be prohibited within flood plain of river or streams. The recommendation was as follows:

Coal Deposit	Federal Coal Recommended For Leasing	Federal Coal Recommended Not to be Leased Due to Resource Conflicts
Ashland	2,867 ACs 208.38 Million Tons	1,120 ACs 99.12 Million Tons

II. Decker-Birney Planning Unit (MFP)

The Decker-Birney MFP was completed in 1974 by the Miles City District Office.

The coal resource allocation decision recommended leasing in the least conflict areas of the Ashland and Otter Creek coal deposits with the provision that mining be prohibited in flood plains.

The recommendation was as follows:

Coal Deposit	Coal Recommended For Leasing	Coal Recommended Not to be Leased Due to Resource Conflicts
Ashland	4,888 ACs 495.3 Million Tons	3,120 ACs 292.7 Million Tons
Otter Creek	18,920 ACs 1,193 Million Tons	18,530 ACs 208 Million Tons

B. Planning Update - Federal Land Review

In 1979 certain coal deposits, including the Ashland and Otter Creek deposits, were included in a planning update. The update further constrained the federal coal recommended for leasing in the MFPs by

applying the federal land review process to these areas. The review included the application of the BLM's unsuitability for mining criteria and the surface owner consultation provision of SMCRA to the areas.

The result of the planning update was the identification of federal coal acceptable for further consideration for coal leasing.

1. Otter Creek Coal Deposit

The results of the planning update are shown on figures 2 and 3.

II. Ashland (D-B) Coal Deposit

The results of the planning update are shown on figures 4 and 5.

III. Ashland (Cw) Coal Deposit

The results of the planning update are shown on figures 6 and 7.

C. Activity Planning

The next step in the federal coal leasing process is activity planning. The major steps in activity planning include industry expressions of leasing interest, USGS tract delineation, tract site specific analysis and a regional environmental impact statement prior to leasing.

A coal activity plan is underway in the Powder River Basin of Montana and Wyoming. The coal areas identified as acceptable for further consideration for coal leasing in the planning update are included. The Regional EIS is scheduled to be completed in December 1981. Lease sales are scheduled to begin in April 1982.

I. Ashland (Cw) Coal Deposit

A tract has been delineated for further leasing consideration in this deposit.

II. Ashland (D-B) Coal Deposit

A tract has been delineated for further leasing consideration in this deposit.

III. Otter Creek Coal Deposit

Two tracts, identified as Northwest Otter Creek and Southwest Otter Creek have been delineated for further leasing consideration in the portion of the deposit west of Otter Creek. No tracts were delineated in the portion of the deposit east of Otter Creek.

Our analysis of the petition allegations includes all of the Otter Creek coal deposit.

3. Response to the Petition

A. Allegations Pertaining to Water Resources

I. <u>Introduction</u>

Items #21 through #25 (page 10) of the petition are understood to be statements of fact or opinion in relation to water resources and do not, alone, constitute allegations of impacts due to future surface mining activity. Items #26 through #30 (pp. 10, 11), #34 and #35 (page 12) are understood to be allegations of potential impacts to water resources as a result of future mining within the petition area. These allegations will be addressed in this section. Item #34 alleges failure to stabilize the soil through surface reclamation and will be addressed in the soil and reclamation section. There will be no attempt to address cummulative water resource impacts resulting from future operations outside the four potential lease areas described herein. Those impact questions are purely speculative at this time and will be covered in subsequent Bureau planning efforts (items #32 and #33).

The several water resource impact issues presented in the petition seem to fall in three broad catagories, that water quality will be impaired in, (1) bedrock acquifers, (2) alluvial aquifers and, (3) the Tongue River if surface mining is permitted in the area. The following analysis and impacts summary will address those catagories with the assumption that mining will take place on all four coal areas depicted on Figure 8.

The hydrologic evaluation presented here should be considered an approximation rather than precise prediction and is not intended to replace a more detailed analysis of the hydrologic aspects of mining which accompanies mine plan development and review. It must be kept in mind that substantially more information on overburden geochemistry, planned location of mine cuts, direction and rate mine expansion, specific proposals for timing and methods of reclamation and hydrologic information of sufficient intensity to evaluate effects of a specific mining operation will be available at the mine plan review stage. However, using simplified methods similar to the analysis referenced in the petition, some quantification of potential effects on mining ground and surface water quality is possible.

The following analysis was prepared as a cooperative effort of the Bureau of Land Management, U.S. Geological Survey-Water Resources Division, Montana District and the Montana Bureau of Mines and Geology.

II. Background

In brief terms, this analysis of potential effects of mining on water quality was conducted by: (1) estimating water quality of mine spoils from available overburden paste-extract analyses, (2) assuming that mine-spoil waters will move down gradient through undisturbed bedrock acquifers after ground-water flow patterns are reestablished (with no geochemical changes occurring in the undisturbed aquifers), (3) assuming that mine-spoil waters transmitted through the mined areas will eventually discharge to alluvial acquifers at rates approximately equivalent to premining rates, and, (4) assuming that mine-spoil waters will ultimately reach the Tongue River and contribute to the total salt load in the river. We view these assumptions to be reasonable based on professional experience and hydrologic investigations conducted in the area.

In the absence of detailed mine plans for the four tracts shown in Figure 1, the assumption is made that the entire areas outlined will ultimately be strip mined. It is further assumed that mining and reclamation activities will comply with State and Federal mine regulations. The assumption that mitigating measures specified in Federal lease proceedings and mine plan reviews such as isolation of toxic spoils, control of runoff, replacement of destroyed wells and springs, and similar protective measures will be diligently pursued is basic to this analysis.

Available Hydrologic Information

Information used in this analysis were collected during several hydrologic studies that have been conducted by the USGS over the past 7 years. Water quality data are available from over 100 wells and springs within the area. Water level measurements have been made in numerous wells in the area and potentiometric maps have been prepared for most of the area. Aquifer characteristics have been determined at test wells drilled in both alluvial and bedrock aquifers.

Current water quality data for several aquifer units within the area are summarized in Table 1. The table contains the locations of sites sampled, the aquifer from which the sample was obtained, and the dissolved-solids concentration. Locations of sampled wells and springs are shown on Figure 9. More complete chemical information including major dissolved constituents and trace constituents are on file in the USGS office in Helena.

Our information is that the existing wells in the shallow bedrock (above Lebo Shale) and alluvial aquifers are being used primarily for livestock drinking water with some domestic use. There is very little if any irrigation use from these wells. The water quality summarized on Table 1 indicates that this water is suitable for livestock use but exceeds EPA recommended levels for human consumption, in most cases (Ref., "Quality Criteria for Water", 1976).

Water Quality in Mine Spoils

The Montana Bureau of Mines and Geology (MBMG), in cooperation with BLM and the USGS, is currently investigating methods to predict water quality in mine spoils. Although their work is continuing and refinement of predictions are anticipated, they have developed an empirical technique for calculating water quality in spoils from overburden paste-extract analyses. Wayne Van Voast, (MBMG personal communications) calculated weighted-average specific conductance values from overburden paste-extract analyses furnished by Water and Power Resources Services and Montco from core holes drilled in the area of interest. Using a conversion factor 0.7, specific conductance of paste extract was converted to dissolved solids content. Van Voast assumed that the upper part of the overburden will, after mining, become the lower part of the spoils. It is recognized that a small amount of this upper part may be reserved for soil augmentation. This upper overburden, after ground water flow patterns are reestablished, would control the water quality in the spoils. Where overburden exceeds 150 feet, Van Voast considered only the upper 100 feet of overburden. Where overburden thickness is less than 150 feet, only the upper 50 feet was considered.

The location of 9 core holes for which paste-extract analyses were available are shown on Figure 10. The calculated dissolved solids content for each site are listed in Table 2. As would be expected, the calculated dissolved solids are highly variable due to differences in overburden geochemistry.

The range of values shown in Table 2 are comparable to dissolved-solids concentrations measured in samples from resaturated mine spoils in the Decker and Colstrip areas as reported by Van Voast in several published reports. The values shown in Table 2 are the expected dissolved solid concentrations that would be added to water flowing through the spoils.

111. Analysis of Potential Water Resource Impacts

The following analysis contains numerous assumptions which are necessary to clarify the computational approach used. These assumptions are believed to be reasonable and reflect the most probable circumstances associated with mining and post-mining conditions for the four coal areas being analyzed, Figure 8.

A. Effects of Mining on Water Quality in Bedrock Aquifers

(1) Ground water flow patterns will be reestablished after mining ceases.

(2) Confining zones (low permeability silt and shale zones) below the mined coal seams will not be destroyed by the mining and reclamation activities.

(3) Mine spoil water moving down gradient through undisturbed bedrock aquifers will not interact with aquifer material to significantly alter the chemical character of the migrating mine spoil water.

(4) The chemistry of mine spoil water will ultimately stabilize with dissolved-solids content equal to premined quality plus the predicted values shown in Table 2.

The coal areas outlined on Figure 8 are all located at the terminal parts of local ground water flow systems. In all cases, direction of ground water flow in the shallow bedrock aquifers which would be affected by mining is toward the stream valleys. Thus, areas where bedrock aquifers would be impacted by migrating mine spoil water are downslope from the mine tracts. No water quality impacts are expected upgradient from the mines. In the absence of detailed mine plans, one must assume that all shallow bedrock wells within the outlined areas are susceptible to water quality changes from migrating mine spoil water.

Wells tapping deeper aquifers (those lying beneath the Lebo Shale Member of the Fort Union Formation) are generally isolated from the shallower aquifers. Water quality changes are unlikely to occur in these zones even if mines are placed directly above them. The Lebo Shale consists of several hundred feet of low permeability siltstones and shales which would prevent downward flow of mine spoil waters.

The paucity of data on overburden geochemistry precludes detailed analysis of post mining water quality in the shallow bedrock aquifers. If the assumption is made that overburden geochemistry shown in Table 2 is representative of the area surrounding each core hole, ground water chemistry can be estimated in a general fashion. Figure 10 shows subareas along the Otter Creek drainage partitioned on the basis of core hole locations.

The dissolved-solids concentrations estimated for the core holes within each subarea delineated on Figure 10 are assumed to be representative of the change in water quality which would prevail in shallow bedrock aquifers after groundwater systems return to equilibrium. Obviously, water quality will very considerably over the area due to variations in overburden geochemistry and mixing of replaced spoils. However, if the core hole data is representative, the overall increase in dissolved solids concentrations should be similar to the values shown on Figure 10.

It is important to note that deeper aquifers are available as replacement sources in the event that shallow wells are destroyed or degraded beyond use. The Tullock Member of the Fort Union Formation lies directly below the Lebo Shale throughout the area. Depth to the top of the unit is dependent on land surface elevation, but is about 700 feet below the floor of the Otter Creek Valley. Several wells have been drilled to the Tullock aquifer and yields of 40 gallons per minute have been reported. Dissolved solids concentrations of water samples from the Tullock aquifer range from 860 to 1770 mg/L (see Table 1). This quality is comparable to or better than the shallow wells. The Fox Hills - lower Hell Creek aquifer lies about 900 feet below the Tullock aquifer. Although no wells have been drilled to that depth in the immediate area, high yielding wells (as much as 200 gallons per minute) have been drilled in nearby areas. Water quality from Fox Hills - lower Hell Creek is often better than from shallower wells for domestic and livestock use. These deeper acquifers generally contain water with high sodium concentrations which would limit their usefullness as sources of irrigation water.

B. Effects of Mining on Water Quality in Alluvial Aquifers

Alluvial aquifers in the Tongue River and Otter Creek valleys are generally more productive than bedrock aquifers. In addition, shallow water tables in the unconsolidated materials can provide subirrigation for crops on the valley floors.

The alluvial aquifers are dynamic systems that respond to inflow and outflow. Water infiltrating from the surface includes precipitation falling directly on the valley floors, irrigation water diverted to crops, flood flows which occasionally spread over the flood plains, and seepage from the stream channels. Water also enters the alluvial aquifers as underflow from upstream areas, from adjacent bedrock aquifers and clinker, and from tributary stream valleys. Water leaves the alluvium as discharge to streams, evapotranspiration, underflow to downstream areas, and withdrawals from wells. Most of the inflow and outflow is highly variable in time and space. During periods of imbalance, water levels in the alluvium rise or fall as storage changes occur.

The variability of inflow and outflow in time and space is complicated by variations in water quality of inflows. The resultant water quality in the alluvial aquifers is extremely variable as illustrated by the dissolved-solids values for the alluvial wells listed in Table 1. The special variatinn in water quality is likely compounded by temporal variations at a given site, but data are unavailable to assess this factor.

Impacts of mining on the water quality in the alluvial aquifers would result from changes which might occur in only one of the numerous sources of inflow to the system. The underflow, or discharge, from adjacent bedrock aquifers to the alluvium would ultimately inject mine spoil water to the system. How this change in inflow might affect the overall quality of the water in the alluvial aquifers is extremely difficult to assess.

A simplified assessment of the total dissolved-solids contribution from the mined areas can be used to illustrate the magnitude of potential mining impacts. To arrive at an estimate, the following assumptions are made:

(1) Ground water flow rates will stabilize at premining rates after mining ceases.

(2) The dissolved-solids concentration in ground water from mined areas will increase by the values shown on Figure 10.

(3) Reclamation practices would minimize infiltration on the mine spoils by encouraging evapotranspiration from reestablished vegetation and by selective replacement of spoils with low permeability near the surface to reduce percolation through the spoils.

The first assumption is based on the precept that ground water flow rates under natural conditions are dependent upon the rate of inflow in the recharge areas. After mining, transmissivities of the mined areas will be different than premining transmissivities, but gradients will adjust to the inflow rate and ground water outflow will eventually be equivalent to premining rates.

Using aquifer transmissivities computed from test wells in each subarea and gradients from water level contour maps, total ground water discharge from each subarea was computed from:

$$Q = T \times I \times W \qquad \text{where}$$

Q = Ground Water Discharge, in ft^3/day
T = Transmissivity, in ft^2/day
I = Gradient, unitless
W = Width of Subarea, in feet

Total dissolved-solids load is them computed from:

$$L = Q \times C \times F \qquad \text{where}$$

L = Dissolved-Solids Load in tons/year
Q = Ground Water Discharge in ft^3/day
C = Dissolved-Solids, in mg/L from Figure 3
F = 1.139×10^{-5}, to convert equation units to tons/year

Table 3C summarizes the calculated dissolved-solids loads from the mine areas. Total dissolved-solids from the entire area would be about 3,530 tons/year, after ground water flow systems reestablish in the mined area. This salt load would be contained in the 84,900 ft^3/day discharge from the mined areas, which represent an average dissolved-solids concentration of about 3,650 mg/L. The total salt load from the mined areas was derived by summing the existing dissolved-solids loads from shallow bedrock aquifers in each subarea (Table 3A), with the additional dissolved-solids loads, in each subarea, caused by mining (Table 3B). A dissolved-solids concentration of 1,740 mg/L was used to represent existing water quality in the bedrock aquifers. This value is the mean dissolved-solids concentration of water samples from 65 wells completed in the Tongue River Member (values from Table 1).

To illustrate the potential impacts of mining on water quality in alluvial aquifers, the Otter Creek Valley from about Fifteenmile Creek to Home Creek was used. This particular section was selected for illustration based on the findings of a seepage run conducted in 1977 (WRI Open-File Report 80-1298) and local geology. The seepage run showed that Otter Creek loses water to the alluvial aquifer downstream from Fifteenmile Creek and begins to gain water from the alluvium near Home Creek. Large amounts of ground water discharge through clinker occurs below Home Creek.

A simplified water budget for the alluvial aquifer in this reach can be written as:

$$Q_{si} + Q_{ai} + Q_{bi} + P = Q_{so} + Q_{ao} + ET$$ where

Q_{si} = Inflow to the alluvium from surface water sources including loss from Otter Creek, tributary streams, and overland runoff.
Q_{ai} = Underflow through the alluvium into the reach.
Q_{bi} = Underflow from adjacent bedrock aquifers.
P = Precipitation falling directly on the valley floor.
Q_{so} = Discharge from the alluvium to Otter Creek at the downstream end of the reach.
Q_{ao} = Underflow through the alluvium out of the reach.
ET = Evapotranspiration from the valley floor.

Precipitation, P, in the area is about 15 inches per year or about 3,410 acre-feet per year over the reach. Evapotranspiration, ET, is about 2 feet per year or 5,450 acre-feet per year over the reach.

Underflow through the alluvium, Q_{ai}, calculated from transmissivity of the alluvial aquifer, width of the valley, and water-table gradient is about 120 acre-feet per year. Underflow out of the reach, Q_{ao}, is about 60 acre-feet per year.

From Table 3, the underflow from adjacent bedrock aquifers to the alluvial aquifer along this reach, Q_{bi}, is about 640 acre-feet per year.

Using these values of inflow and outflow in the water budget equation, one arrives at:

$$Q_{si} = Q_{so} + 1{,}340 \text{ acre-feet per year}$$

This shows that inflow from Otter Creek and other tributaries must exceed the ground-water discharge to Otter Creek by about 1,340 acre-feet per year.

A second equation can be written for dissolved-solids inflow and outflow to the reach:

$$(Q_{si} \times C_{si} + Q_{ai} \times C_{ai} + Q_{bi} \times C_{bi}) = (Q_{so} \times C_{so} + Q_{ao} \times C_{ao})$$ where

C_{si} = Dissolved-solids concentration in surface water recharging the alluvial aquifer.
C_{ai} = Dissolved-solids concentration in alluvial inflow.
C_{bi} = Dissolved-solids concentration in bedrock inflow.
C_{so} = Dissolved-solids concentration in ground water discharge to Otter Creek.
C_{ao} = Dissolved-solids concentration in alluvial outflow.

Other symbols are as defined earlier.

The dissolved-solids concentration in surface water inflow, C_{si}, varies considerably depending upon the flow in Otter Creek. During spring runoff, dissolved solids may be as low as 228 mg/L. During low flow conditions, dissolved solids have been measured as high as 3,540 mg/L. However, most recharge would occur during periods of high runoff and the average during this period may be about 380 mg/L.

Dissolved-solids in the alluvial inflow, C_{ai}, averages about 3,200 mg/L at the upstream end of the reach.

Dissolved-solids in bedrock inflow, C_{bi}, varies considerably, but 1,740 mg/L as shown in Table 3A, would be about average along the reach.

Dissolved-solids in ground-water discharge to Otter Creek, C_{so}, measured in 1977 was about 3,050 mg/L. This concentration would also apply to ground water underflow, C_{ao}.

Substituting these concentrations into the dissolved-solids equation:

$$(Q_{si} \text{ acre-ft/yr} \times 380 \text{ mg/L} + 120 \text{ acre-ft/yr} \times 3{,}200 \text{ mg/L} + 640 \text{ acre-ft/yr} \times 1{,}740 \text{ mg/L}) = (Q_{so} \times 3{,}050 \text{ mg/L} + 60 \text{ acre-ft/yr} \times 3{,}050 \text{ mg/L})$$

Substituting $Q_{si} = Q_{so} + 1{,}340$:

$$(Q_{so} + 1{,}340 \text{ acre-ft/yr}) \times 380 \text{ mg/L} + \ldots\ldots$$

Q_{so} = 683 acre-ft/yr
Q_{si} = 2,023 acre-ft/yr

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If one assumes that mining would not disrupt the water budgets, the only change that occurs after mining would be an increase in dissolved-solids introduced as underflow through aquifers, C_{bi}. From Table 3C, postmining dissolved-solids concentration in bedrock inflow would average about 3,650 mg/L.

Using that value in the dissolved-solids equation and solving for postmining dissolved-solids concentration in discharge to Otter Creek and alluvial outflow, C_{so} and C_{ao}, one arrives at 4,700 mg/L for average dissolved-solids concentration in alluvium.

This simplified approximation indicates that overall water quality in alluvium of Otter Creek might increase 1,650 mg/L as a result of mining. However, it is important to note that dissolved-solids concentrations in alluvium is highly variable depending upon the quantity and quality of nearby inflow. The variability would likely prevail after mining and areas of better or poorer quality than 4,700 mg/L would be expected.

As in the case of bedrock aquifers, deeper sources of water are available to replace any alluvial wells degraded to an unuseable quality.

C. Effects of Mining on Water Quality in the Tongue River

Calculations of water quality changes in the Tongue River as a result of mining in the coal areas outlined in Figure 8 are more easily made because all water in the area ultimately must enter the Tongue River or be lost to evapotranspiration. Simply stated, after equilibrium conditions are attained, any salt load added to the system by mining must exist the system as dissolved salts in Tongue River discharge.

Maximum withdrawals from the Tongue River for irrigation occur in July. Therefore to simplify calculations, dissolved-solids loads for mean, the 30 day low flow, and the instream flow rate specified by the Missouri River Basin Commission for this most critical month were computed.

Streamflow conditions in the Tongue River at Miles City for July were obtained from USGS Water Resources Investigations Report 80-41, which supplied the mean and the 30-day low flow; the instream flow was obtained from Missouri River Basin Commission Level B Study. Mean streamflow for July is 30,191 acre-feet, the 30-day low flow is 3,671 acre-feet and the instream flow is 9,280 acre-feet. To compute dissolved-solids loads, it was necessary to determine the dissolved-solids concentration measured during streamflows close to the above stated streamflows. Geological Survey streamflow records for July revealed that 1970 had streamflow of 30,990 acre-feet, 1954 had a streamflow of 3,130 acre-feet and 1966 had a streamflow of 10,100 acre-feet.

The specific conductance values measured in July in the Tongue River at Miles City during 1954, 1966, and 1970 were statistically analyzed to determine the mean for each July. Then, all specific conductance values measured concurrently with dissolved-solids concentration at Miles City were regressed to obtain the following prediction equation:

$$\log_{10} DS = -.4072 + 1.0768(\log_{10} SC)$$

Where DS is dissolved-solids concentration in milligrams per liter and SC is specific conductance in micromhos per centimeter. The correlation coefficient of the equation is 0.98. From this equation, the mean dissolved-solids concentration was determined from the mean specific conductance. The mean dissolved-solids concentrations are shown in Table 4 under the "premining dissolved-solids" column.

The dissolved-solids load at Miles City could then be calculated as follows:

$$L = DS \times Q \times F$$

where L is dissolved-solids load in tons, DS is dissolved-solids concentration in milligrams per liter, Q is streamflow in acre-feet, and F is .00136 (a factor to convert equation units to tons). The dissolved-solids loads at Miles City are shown in Table 4 under the "premining dissolved-solids" column.

The dissolved-solids load input from the four proposed lease tracts after mining was estimated as 1,849 tons per year, as calculated in Table 38. For simplicity, the monthly rate was assumed to be about 154 tons per month.

The post-mining loads at Miles City were computed as simply the sum of the premining load plus the additional load from the mined area. Dissolved-solids concentration is a more meaningful variable; loads were therefore converted to concentrations as follows:

$$DS = L \div Q \div F$$

Where DS is dissolved-solids concentration in milligrams per liter, L is dissolved-solids load in tons, Q is streamflow in acre-feet, and F is .00136 (a factor to convert equation units to milligrams per liter). Finally, the percentage changes in concentration were calculated as follows:

$$C = \frac{A}{B} \times 100$$

Where C is percentage change, A is post mining concentration in milligrams per liter, and B is premining concentrations in milligrams per liter.

This simple technique illustrates the magnitude of expected impacts on water quality in the Tongue River as a result of mining the four tracts coal areas outlined on Figure 8. Under mean flow conditions in July, mining might increase dissolved-solids concentrations about 3 mg/L. Under 30 day low flow conditions, dissolved solids concentrations might increase about 36 mg/L. For the three flow conditions analyzed, the maximum percentage increase was about 4 percent.

Table 1.—Dissolved Solids Content of Ground Water

Assigned Well No. (Fig. 2)	Location (Local Number)	Aquifer[1]	Dissolved Solids mg/L
1	03S45E19DDBC	TGRV	840
2	03S45E19DDBD	TGRV	840
3	03S45E22BAAB	TGRV	1480
4	03S45E22BBBA	TGRV	1120
5	03S45E23DADA	TGRV	720
6	03S45E24ACDA	TGRV	2720
7	03S45E26ADAC	TGRV	3620
8	03S45E26DBCB	TGRV	3430
9	03S45E27ACBC02	TGRV	2580
10	03S45E31DCDA	TGRV	3460
11	03S45E32DDAC	TGRV	850
12	03S45E33BCBB	TLCK	860
13	03S45E34AACD	TGRV	860
14	03S45E34AACD	TGRV	4380
15	03S45E34CACD	TGRV	5720
16	03S45E34DABA	TGRV	2570
17	03S44E13DBBA	TLCK	1390
18(S)	03S45E01ABDD	TGRV	1790
19	03S45E03BADD	TGRV	3510
20	03S45E05DBBC	TGRV	1100
21	03S45E09DDAD	TGRV	2410
22	03S45E10BACD	TGRV	1460
23	03S45E12BDCB	TGRV	1010
24	03S45E12BDCB02	ALVM	1420
25(S)	03S45E12BDCD	TGRV	980
26	03S45E13DCBC	TGRV	2530
27	03S45E15DDDA	TGRV	1360
28(S)	04S44E24ABBB	TGRV	4680
29	04S45E02BDDD	TGRV	2100
30	04S45E02CDDB	TGRV	1850
31	04S45E02DACD	TGRV	1250
32	04S45E04DBCA	TGRV	640
33	04S45E04DBDB	ALVM	1930
34	04S45E09CAAD	TLCK	1410
35	04S45E09DDBA	TLCK	1530
36	04S45E15CCDD	LEBO	970
37	04S45E15DBBC	TGRV	1470
38	04S45E19DADC	TGRV	3520
39	04S45E20CCAD	TGRV	1850
40	04S45E22ADCC	TGRV	920

(S) Denotes spring.
† Estimated from specific conductance.
If no dissolved solids value listed, chemical analysis not complete.
[1] Aquifer Codes are: TGRV - Tongue River Member of the Fort Union Formation.
LEBO - Lebo Member of the Fort Union Formation.
TLCK - Tullock Member of the Fort Union Formation.
CLKR - Clinker Member of the Fort Union Formation.

Assigned Well No. (Fig. 2)	Location (Local Number)	Aquifer[1]	Dissolved Solids mg/L
41	04S45E23CCCB	TGRV	620
42	04S45E27ACCD	TGRV	600
43	04S45E27DBAB	ALVM	1950
44	04S45E28ADDA	TGRV	3090
45(S)	04S45E30DDBB	TGRV	1350
46(S)	04S45E32CADB	TGRV	2080
47	05S45E03ABCD	TGRV	1110
48	05S45E03ACBB	TLCK	1110
49	05S45E04BBDD	TGRV	620
50(S)	05S45E06DAAD	TGRV	1120
51(S)	05S45E08BDDA	TGRV	1310
52	05S45E11BBAC	TLCK	1650
53	05S45E11CDCD		1580
54	05S45E14AAAD	TLCK	1770
55	05S45E15ADDD	TLCK	1540
56(S)	05S45E18AACD	TGRV	2510
57	05S45E26BABB	ALVM	2180
58	05S45E27BDDB	TGRV	920
59	05S45E28BBBA	TGRV	1100
60(S)	05S45E29ADDC	TGRV	2450
61	05S45E35BABA	TGRV	510
62	05S45E35BABD	ALVM	2100
63	03S45E05DBAA01	TGRV*	1782
64	03S45E05DBBB01	ALVM	1021
65	02S44E35DAAB02	ALVM	983
66(S)	03S44E12BDDA01	TGRV**	315
67(S)	03S45E06AAAD01	TGRV	1545
68	02S45E32DABD01	TGRV	1800
69	02S45E32BBBE01	TGRV	1720
70	03S45E06BABB01	ALVM	1020
71	02S44E35DAAB01	ALVM	949
72(S)	03S45E32DABD02		796
73(S)	03S45E05DBBB02		905
74	03S45E19DCCD01	TLCK	1700†
75	03S45E30BDCB01		
76			
77	03S45E33BCDA01	TLCK	1450†
78	03S45E33CBDA01	TGRV	900†
79	04S45E05AAAA01	ALVM	
80	04S45E06DBDB01	TGRV	940

*Knobloch
**Knobloch clinker

(S) Denotes spring.
† Estimated from specific conductance.
If no dissolved solids value listed, chemical analysis not complete.
[1] Aquifer Codes are: TGRV - Tongue River Member of the Fort Union Formation.
LEBO - Lebo Member of the Fort Union Formation.
TLCK - Tullock Member of the Fort Union Formation.
CLKR - Clinker Member of the Fort Union Formation.

Assigned Well No. (Fig. 2)	Location (Local Number)	Aquifer[1]	Dissolved Solids mg/L
81	04S45E06DBDB02	TGRV	
82	04S45E04BAD001	ALVM	2400†
83	04S45E04BDAA01	ALVM	2100†
84	04S45E04BDDB01	ALVM	2700†
85	04S45E04BDDB02	ALVM	
86	04S45E04CAAC01	ALVM	2000†
87	04S45E07CABA01	TGRV	
88	04S45E08DDAD01	TGRV	
89	04S45E09DCAA01	ALVM	
90	04S45E10CCBC01	ALVM	
91	04S45E15BCDD01	ALVM	
92	04S45E15CBCD01	TGRV	
93	04S45E15CCAC01	ALVM	
94	04S45E22BBCC01	TGRV	
95	04S45E16CDAC01	TGRV	
96	04S45E17CCDD01	TGRV	
97	04S45E21	TGRV	
98	04S45E22CDDD01	TGRV	800†
99	04S45E28ADDA01	TGRV	900
100	04S45E28BDDD02		
101	04S45E28BDDD01	TGRV	1340
102	05S45E05AAAB01	TGRV	
103	05S45E04ABCC02		
104	05S45E04ABCC01	TGRV	2640
105	05S45E08BBCC01	TGRV	
106	05S45E09DDAA01	TGRV	2100†
107	05S45E10DDCD01	TGRV	
108	05S45E16DBCB01	TGRV	
109	05S45E23BBAA01	1 TGRV Ss	600†
		2 TGRV Coal	750†
		3 TGRV Ss	2100†
110	05S45E23BBAA04	ALVM	2300†
111	05S45E23ABCB01	ALVM	2800†
112	05S45E23ABCA02	ALVM	3300†
113	05S45E23ABCA01	ALVM	2800†
114	05S45E23ABDA01	5 TGRV Ss	550†
		6 TGRV Coal	1250†
		7 CLKR	2100†

(S) Denotes spring.
† Estimated from specific conductance.
If no dissolved solids value listed, chemical analysis not complete.
[1] Aquifer Codes are: TGRV - Tongue River Member of the Fort Union Formation.
LEBO - Lebo Member of the Fort Union Formation.
TLCK - Tullock Member of the Fort Union Formation.
CLKR - Clinker Member of the Fort Union Formation.

Table 2.--Calculated Dissolved Solids Content of Mine-Spoil Water from Paste-Extract Analyses (Van Voast, MBMG)

Location of Core Hole	Calculated Dissolved Solids in mg/L	Source of Paste-Extract Analyses
2S45E30BCB	1264	MONTCO
3S45E 8DCB	1375	MONTCO
3S45E34AA	6040	WPRS
3S45E34CAC	2920	WPRS
4S45E 6DBD	2135	WPRS
4S45E26C	1435	WPRS
4S45E28CAA	1460	WPRS
5S45E 4BAD	5160	WPRS
5S45E12BDB	1920	WPRS

Table 3.--Calculated Dissolved-Solids Loads to Alluvial Aquifers from Mined Areas

Table 3A--Existing dissolved-solids loads from shallow bedrock aquifers in mine areas.

Area (See Fig. 3)	Transmissivity (ft^2/day)	I (unitless)	Width (feet)	Discharge (ft^3/day)	Concentration (mg/L)	Load (tons/yr)
1	20	.02	13,200	5,300	1,740	105
2	10	.02	15,840	3,200	1,740	63
3	440	.004	15,840	27,900	1,740	553
4	25	.005	15,840	2,000	1,740	40
5	13	.01	10,560	1,400	1,740	28
6	150	.01	13,200	19,800	1,740	393
7	150	.01	13,200	19,800	1,740	393
8	10	.02	18,480	3,700	1,740	73
9	10	.01	18,480	1,800	1,740	36
TOTAL				84,900		1,684

Average concentration = 1,740 mg/L

Table 3B--Additional dissolved-solids loads from mined areas.

Area (See Fig. 3)	Transmissivity (ft^2/day)	I (unitless)	Width (feet)	Discharge (ft^3/day)	Concentration (mg/L)	Load (tons/yr)
1	20	.02	13,200	5,300	1,260	76
2	10	.02	15,840	3,200	1,370	50
3	440	.004	15,840	27,900	2,135	678
4	25	.005	15,840	2,000	4,480	102
5	13	.01	10,560	1,400	2,135	34
6	150	.01	13,200	19,800	1,460	329
7	150	.01	13,200	19,800	1,435	324
8	10	.02	18,480	3,700	5,160	217
9	10	.01	18,480	1,800	1,920	39
TOTAL				84,900		1,849

Average Concentration = 1,912 mg/L

Table 3C--Total dissolved-solids load to alluvial aquifers from mined areas.

Total Load = 1,684 + 1,849 = 3,533 tons/year
Total Discharge = 84,900 ft^3/day
Average Concentration = 3,533/(84,900 x 1.139 x 10^{-5})= 3,650 mg/L

IV. Summary of Impacts and Mitigating Measures

When assessing possible impacts it is important to note the preceding analysis was based on an extreme developmental scenario. The development assumption is that the entire acreage of all four coal areas shown on Figure 8 would have been mined and would consist of disturbed overburden materials (spoils). Further, that the first pore-volume of ground water to pass through these resaturated spoils would do so at the same time over the entirety of the four areas. This is a very unlikely situation and undoubtedly biases the analysis results on the side of high dissolved solids loading.

A. The summary of predicted impacts and their significance are discussed by category as presented in the analysis.

<u>Shallow Bedrock Aquifers</u>: Water quality impacts will be limited to the mined areas and downgradient in horizontal extent and above the confining Lebo Shale in vertical extent. The gradient is toward the valley bottom in all cases. Wells in mined areas will obviously be eliminated, along with the need for them, until mining is completed and overburden/soil material is replaced. Down gradient dissolved-solids concentrations are estimated to reach an average level of about 3650 mg/l. This concentration may affect the desirability for stockwater, but not preclude such use, as it is well within the range commonly used for stockwater in SE Montana. Such concentrations, however, certainly exceed recommended levels for domestic use.

<u>Alluvial Aquifers</u>: Water quality impacts to the alluvial system would result from underflow from adjacent mined areas. The post-mining dissolved solids concentration entering the alluvium is estimated to average 3650 mg/l. This contribution is estimated to result in an average concentration in the alluvium of 4700 mg/l. Point values could vary considerably above and below that average. Wells in the alluvial bottoms may be serving as both domestic and stockwater sources. Again, this dissolved-solids level may not preclude livestock use, but would further render the water undesirable for domestic use. Based on Table 1 values, the alluvial water greatly exceeds the recommended concentration of dissolved solids for domestic use at present (ref. EPA, "Quality Criteria for Water," 1976).

In locations of a very shallow water table, there may be some subirrigation of pasture or croplands. Where the water table is less than three feet deep, increased dissolved-solids concentration could reduce yields of small grain crops. A water table of 3 to 10 feet so affected could reduce yields of deep rooted perennials such as alfalfa.

Table 4.—Status of Pre- and Post-Mining Dissolved-Solids Concentrations in the Tongue River at Miles City During July under Otter Creek Mining Scenario

Streamflow (AF)	Pre-Mining Dissolved-Solids Load (Tons)	Pre-Mining Dissolved-Solids Concentration (mg/L)	Dissolved-Solids Load From Mining (Tons)	Post-Mining Dissolved-Solids Concentration (mg/L)	Percent Change In Dissolved-Solids Concentration
Mean (30,990)	14,909	354	154	357	+0.85
30-Day Low-Flow (3,130)	3,789	890	154	926	+4.04
Instream (10,100)	7,432	541	154	552	+2.03

Many unknowns at the present time preclude a meaningful analysis of this question. This is a very site-specific question, bearing heavily on the relative proximity of any proposed mining activity and impact susceptible cropland. A detailed analysis by more intensive field investigations will accompany the development of any mining plan(s) in these potential lease areas. This analysis is required in the Federal "Surface Coal Mining and Reclamation Operations" Regulations under Part 780.

Tongue River: The estimated dissolved-solids loading from the potential mine areas was applied to three river flow levels in the month of July, the peak irrigation period. The change in concentration at mean July streamflow, at Miles City, is estimated to be an increase of less than one percent. At the 30-day low flow, the increase in the concentration is estimated to be 4 percent. This change is not significant to irrigation uses of water from the Tongue. We believe that dissolved-solids loadings which would result from flood irrigating cropland of an acreage comparable to the potential mine areas would be considerably higher.

B. Mitigation Opportunities. Since the predicted impacts on the water quality of the Tongue River are not considered significant in magnitude, mitigation will not be addressed.

As discussed in the preceding analysis, deeper aquifers are available as replacement well water sources for both the shallow bedrock (above the Lebo Shale) and alluvial aquifers. The Tullock member is known to produce good yields for livestock and domestic uses at a quality comparable to existing shallow wells. Better quality water may be available from the lower Fox HillsHell Creek aquifers. Some local users have seen fit to draw water from the Tullock without the impetus of mining.

B. Allegations Pertaining to Soils

I. Introduction

Allegations concerning soils fall into the following three categories.

A. Extent of sodic and/or salty soils.

Allegation No. 12 is a key allegation concerning soils. It states, "Reclamation of the area is not technologically or economically feasible because of a combination of sodic and/or salty soils and shallow recoverable top soils." Allegations 13, 14, 15 and 18 are all related to 12, since they all deal with salts or sodium in the soil.

B. Soil erosion and river sedimentation.

Allegations 20 and 34 address soil erosion and sediment loads in the Tongue River.

C. Movement of sodium and salts.

Allegations 16, 17 and 19 address upward migration of sodium and translocation of salts.

II. Background

A. Data sources

Soils in the petition area have been mapped by the Soil Conservation Service (SCS) as part of their technical services to promote soil and water conservation. The areal extent of soils in the area have been reproduced on a soils map included as figure 11. This information was taken from the Powder River Soil Survey (SCS) and field mapping sheets of Rosebud County (SCS). Details on the character of each soil can be found in SCS documents.

The Department of Interior, Bureau of Land Management (BLM) and Bureau of Reclamation (now Water and Power Resources Service (WPRS)) conducted highly detailed soils and overburden investigations within these coal areas. These are called the Energy Mineral Rehabilitation Inventory and Analysis studies (EMRIA). These areas were selected as representative of larger areas and provide data for reclamation objectives. See figure 12. The following is a list of those site specific (EMRIA) reports:

1. EMRIA #1 Otter Creek Study Site 1975
2. Dam Creek Study Site
   Otter Creek Coalfield Mt. 1977

3. Otter Creek East Study Site
   Otter Creek Coalfield Mt. 1977
4. Shy/6 Study Site
   Otter Creek Coalfield Mt. 1978
5. Chromo/4 Study Site
   Otter Creek Coalfield Mt. 1978
6. Newell/28 Study Site
   Otter Creek Coalfield Mt. 1978

B. General Nature of Soils

Soils of the area can be grouped into two major classes, 1) alluvial and 2) residual: The alluvial soils are deep (greater than 40"). The residual soils are moderately deep (greater than 20" but less than 40") and shallow (less than 20").

The alluvial soils occur on floodplains, terraces and fans where the loamy sediments derived from the erosion of the uplands have accumulated.

These alluvial soils are represented by well developed Aridisols and provide the most suitable soils in the area for sources of topsoil, subsoil and other soil reconstruction material.

The residual soils are generally poorly developed Entisols found on ridges, knolls and sideslopes of the sedimentary uplands. Most of these soils are not well suited for topsoil sources, due to thin topsoil layers. They are, however, a source of subsoil and soil reconstruction material.

C. Data Used to Determine Suitability of Soils for Reclamation

A detailed analysis was made of the four potential coal lease areas within the petition area. These were 1) Southwest Otter, 2) Northwest Otter, 3) Ashland-Decker Birney and 4) Ashland-Coalwood.

Guidelines used to determine each soils suitability as a plant growth medium was of USDA-SCS standards (National Soils Handbook Table 403.6(a)).

This Table lists the criteria needed to judge each soil horizon according to its suitability as reconstruction material for drastically disturbed areas. Soil properties considered were: sodium, salinity, lime content, soil reaction (pH), available water capacity, erosion susceptibility, texture and amount of course fragments. It should be noted there are other soil properties in addition to sodium and salts that can render a soil unsuitable as plant growth material. These additional properties (as shown above) were included in this analysis.

Acreage was tabulated for each soil within the four coal areas. According to the above criteria, the acre feet of soil of good, fair and poor quality was calculated (by judging each horizon) and then summarized for each area. The acre feet of soil in good and fair quality were combined (and considered as material suitable for reconstruction.) The depth of soil in each category was then calculated and is shown as follows.

Summary of Soil Quality by Volume and Depth

Site	Total Acres	Soils of Poor Quality (Acre Feet)	Depth Poor Soil (Inches)	Soils of Good and Fair Quality (Acre Feet)	Depth of Good and Fair Soil Soil (Inches)
Southwest Otter	7,443	12,557	20	8,586	14
Northwest Otter	5,504	9,216	20	5,612	12
Ashland-Decker Birney	5,528	4,706	10	4,202	9
Ashland-Coalwood	6,854	8,392	15	11,162	19
Totals	25,329				

III. Impacts of Mining

Following are the results of the site specific analysis of the potential coal lease areas.

1. Extent of salty, sodic and excessive lime soils. This discussion concerns allegations 12, 13, 14, 15 and 18, pertaining to extent of sodic and salty soils. Excessive lime has been added to this group. Soils fitting this group were tabulated by acres to determine their areal extent. This is shown below by each potential coal lease area.

Soils Affected by Salts, Sodium and Lime

Site	Acres Affected	% of Total Area	Soil Volume Affected (Acre Feet)	% of Total Volume Affected
Southwest Otter	6,249	84%	10,085	48%
Northwest Otter	4,559	83%	7,671	52%
Ashland-Decker Birney	4,781	87%	4,351	49%
Ashland-Coalwood	6,854	75%	5,623	29%

Seventy-five to eighty-seven percent of the total surface acres are affected by salts in some form, as excessive lime, high soluble salts or sodium. Soil volume, however, is a more realistic approach to assess reclaimability. Therefore, soil volume (in acre feet) that is affected by some form of salts was also calculated.

Even though 75 to 87% of the surface acres are adversely affected by salts, only 1/3 to 1/2 of the total soil volume is adversely affected. To realistically evaluate reclaimability, however, other properties that cause degraded soil quality must be considered. By adding other properties (in addition to salt, sodium and lime), the volume of poor quality soils even becomes greater. The total volume of poor quality soils are shown in the summary table of the previous section (B.3. Data Used to Determine Suitability of Soils for Reclamation.) In most cases, the poor quality soils are more than half of the total soil volume.

Nevertheless, the volume (acre feet) of soil in good or fair quality is sufficient to cover the reconstructed mined land to a depth of 9 to 19 inches if spread evenly over each of four coal lease areas. This is adequate soil depth of suitable quality to reestablish vegetation on the mined area; especially if deep soils of suitable quality are used to replace poor quality soils (which are usually shallow.)

Site specific studies done by BLM and Water and Power Resources under the Energy Mineral Rehabilitation Inventory and Analysis (EMRIA) program has shown there is sufficient material in the upper 10 feet of overburden to reconstruct a productive soil profile to the depth of 30 inches, or more, if desired.

A technical and economically feasible method would be to stockpile all suitable topsoil (as state and federal law stipulates.) In addition, suitable material selected from the upper overburden and stockpiled in sufficient quantities could be used to supplement reconstruction of a productive soil of desirable depth.

Such a procedure would provide a more productive land than is presently on the site; i.e., shallow, low productive soils presently in the area would be eliminated.

2. Soil Erosion and River Sedimentation (allegations 20 and 34.) During land disturbance caused by mining, there is a potential for temporary high erosion and high source of sediment in runoff. Catchment basins are required by law and will aid in reducing high sediment runoff.

Furthermore, due to the high amount of soils and overburden suitable for plant growth in the area, future vegetative productivity and vegetative cover would likely be greater than at present, due to the potential for restructuring the land to be more productive than before mining. Therefore, future erosion (after mining) would likely be less than at present.

3. Release of salts and upward migration of sodium (allegations 16, 17 and 19). Translocation of salts and/or sodium will depend upon 1) annual soil moisture penetration, 2) depth and nature of the restructured soils and 3) final placement of saline or sodic material.

Annual soil moisture penetration has much to do with the translocation of salts and/or sodium. Eastern Montana soils display a long term record of annual soil moisture penetration. This is evidenced by accumulation of calcium carbonate in the lower horizons.

For example, the Clca horizon of Thurlow clay loam typically begins at 16 inches, the B3ca horizon in the Fort Collins loam typically begins at the 18-inch depth and the Clca of the Farland silt loam begins at 25 inches. These horizons are long term records of soil moisture penetration and therefore serve as a reliable guide in determining the depth of soils to reconstruct on lands to be used for native range (most of these areas in question are in this use at present).

Soils more shallow than 16 to 25 inches could experience considerable pumping of salts upward from underlying material high in sodium or salts. Therefore, if reconstructed soils are deepened to 30 inches, a buffer zone would be created to minimize upward pumping of salts or sodium migration.

The foregoing discussion of this section (C.1.a.) illustrates the presence of adequate salt-free plant growth medium on these coal areas to bury saline or sodic material (soil or overburden) at sufficient depth in the reconstructed soil profile to avoid serious salt or sodium movement. A 30 inch depth would be adequate for future rangeland soils but a greater depth would be required for soils to be cropped (i.e., under fallow or irrigation.)

IV. Summary of Soils Impacts and Conclusions

The assessment of reclamation potential in this area was determined from two sources: 1) SCS order 2 soil surveys from Powder River and Rosebud Counties and 2) EMRIA data from BLM and WPRS. These data indicate soil conditions are adequate for satisfactory reclamation of the land if the sites are surface mined. Soils and topographic features are best suited for returning the sites to range land use. A few small areas will be suitable for small grain production. A 30-inch depth of good and fair quality plant growth material would insure successful reclamation for future rangeland use. Deeper soils must be reconstructed if the land is to be farmed following mining.

Four potential coal lease areas (within the petition area) were analyzed in detail. These were Southwest Otter, Northwest Otter, Ashland-Decker Birney and Ashland Coalwood.

A major reclamation concern involves sodium and salt content of the soils in the area. This is the subject of allegations 12, 13, 14, 15 and 18.

Soils affected by salts and sodium, as well as excessive lime, cover 75 to 87% of the land in the four coal lease areas. Soil volume adversely affected, however, amounts to only 1/3 to 1/2 of total soil volume.

Considering all soil properties that adversely affect reclaimability, there is still sufficient plant growth material of good or fair quality (according to USDA standards) that would cover the reconstructed mined land to a depth of 9 to 19 inches, if spread evenly over each of the four coal areas.

This appears to be adequate soil to vegetate the mined area. This 9 to 19 inch depth would be the most important part of the 30 inch depth needed to be successful in eastern Montana. The depth of soil could easily be supplemented by borrowing suitable material near the surface of the overburden. EMRIA studies have shown suitable material is present somewhere within the upper 10 feet of the overburden.

This reconstruction procedure appears to be technologically, as well as economically, feasible since all that is involved is selective placement of the soils and overburden during and following the mining process.

Allegations 20 and 34 concern soil erosion and sedimentation of the Tongue River. During mining, there is a potential for high erosion and high sediment in runoff; but required catchment basins reduce this hazard to water degradation.

Also, due to the high amount of favorable plant growth medium in the area, future soil erosion would likely be less since present natural shallow soils of low vegetative cover could be eliminated; and future vegetative cover would be greater.

Translocation of salts and/or sodium is the subject of allegation 16, 17 and 19. The behavior of salts and/or sodium will depend on 1) annual soil moisture penetration, 2) the depth and nature of the restructured soils and 3) final placement of saline or sodic materials.

moisture penetration in most eastern Montana soils varies from 16 to 25 inches in depth. These are the depths where calcium carbonate begins to accumulate. These depths should be used as a reliable guide to reconstruct lands to be used for range. The translocation of salts and sodium will primarily occur within these depths (16-25 inches.) Therefore, reconstruction of a soil at least 30 inches deep will create a buffer zone which will minimize upward pumping of salts or migration of sodium.

In final conclusion, with some care in selection and placement of soils and overburden, soils can be reconstructed following mining of this area that would be more useful and more productive than before mining.

APPENDIX D.

THEORETICAL EFFECTS OF HYPOTHETICAL MINE SPOILS ON QUALITY OF GROUND WATER ALONG THE TONGUE RIVER

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Theoretical changes in water quality were estimated using the following mass-balance relationship:

Inflow from upstream alluvium (rate times quality)	+	Recharge from the surface (rate times quality)	+	Inflow from coal, overburden, or spoils (rate times quality)	=	Outflow from alluvium (rate times quality).

Specific conductance (SC) of water is the parameter examined because of its pertinence to agricultural use. Another characteristic, sodium absorption ratio (SAR) is addressed in a more general manner. No changes in ground-water flow rates are assumed.

Manipulation of the mass-balance relationship into terms of changes in SC (see attachment 1) gives the following simplified equation:

$$\Delta \text{SC in alluvium} = \frac{(\text{inflow rate from alluvium})(\Delta \text{SC}) + (\text{inflow rate from coal, overburden, and spoils})(\Delta \text{SC})}{\text{outflow rate from alluvium}}.$$

Values of input were estimated by various methods:

1. Inflow from upstream alluvium:

   a) Rate: The component of ground-water flow parallel to the river was calculated from the Darcy equation using an estimated transmissivity and gradient. Transmissivity was estimated to be about

5,000 feet squared per day (ft^2/day); this is equivalent to an average saturated thickness of about 30 feet, and an average hydraulic conductivity of about 170 feet per day (ft/day). Gradient was estimated to be that of the Tongue River Valley as it crosses the petition area (.00128 ft/ft). Valley width used in the calculation was 3,500 feet.

b) Quality: For the petition area, 23 SC values and 21 SAR values for wells completed in alluvium along the Tongue River were found in reports by Montco (1981, table Bc11-1), Woessner and others (1980, p. 178), and Hopkins (1973), and in Montana Bureau of Mines and Geology files. All of them represent ground water south of Ashland; there are no data on alluvial water quality in the downstream third of the petition area. In the upstream two-thirds, the quality of water in the alluvium is diverse; SC values range between about 900 micromhos per centimeter (µmhos/cm) and about 2,900 µmhos/cm, and SAR values range between 1 and 50. Mean SC is 1,490 µmhos/cm; the median is 1,360. Mean SAR is 5.4; the median value is 2.6. No trend of increase or decrease of either paramenter in the downstream direction is discernible, and the assumption is therefore made that there is no change with distance during pre-mining conditions. No input of actual alluvial-water quality is needed in the equation; only additions of SC are calculated.

2. Recharge from surface:

a) Rate: This parameter included direct infiltration from rainfall and snowmelt, infiltration of runoff encountering the alluvium from tributaries and valley walls, and any other waters not specified in the equation. Rate of input is .25 feet per year (ft/yr) rounded from values measured by Woessner and others (1980, p. 122). Alluvium in the petition area underlies a surface of about 930 million square feet (44.5 miles long and .75 miles wide), and the implied recharge on a daily basis is about 637,300 cubic feet per day (ft^3/day).

b) Quality: Recharge from surface can be expected to be highly dilute. The SC is an unknown, but is assumed not to change after mining.

3. Inflow from coal, overburden, and spoils:

a) Rate: Woessner and others (1980, p. 225) used an inflow rate of 6,350 cubic feet per day per mile (ft^3/day/mi) parallel to the valley in their Logging Creek model. For the Montco area (permit application, 1981), average gradient toward the river is about 40 feet per mile (map V-2-2); from their aquifer-test data (table Bb-6), an average cumulative transmissivity of the McKelvey, Nance, and Knobloch coal beds of about 110 ft^2/day appears reasonable. The implied rate of ground-water flow in them is 4,400 ft^3/day/mi. For input to the flow equation, a value of 5,000 ft^3/day/mi is used along each side of the valley within the petition area (44.5 miles), implying a total input from the coal beds and interburden of 445,000 ft^3/day. Postmining flow through spoils is assumed to be the same.

b) Quality: Specific conductance and SAR values for ground waters in coal-bed and interburden aquifers were averaged from 8 analyses published by Woessner and other (1980, p. 434-526) and 17 analyses listed by Montco (table Bc11-1). Average specific conductance was 3,300 µmhos/cm; average SAR was 36.5. Hypothetical spoils-water inputs to the balance were developed for separate parts of the area. SC and SAR values are mentioned in the discussion of each subarea.

4. Outflow from alluvium:

a) Rate: This is the quantity of water discharging from alluvium in the petition area. Most of it discharges to the river; some is lost to evapotranspiration, and some flows northward across the area's northern boundary. The quantity of flow is equal to the sum of flows entering the system, and is therefore 1,102,300 ft^3/day.

b) Quality: The assumption was made that there is no trend of changing quality with distance downstream in the premining system. Postmining changes of SC over downstream increments area calculated with the balance equation.

Sector I

Sector 1 is the part of the petition area upstream from Cook Creek. In this sector, hypothetical mining along both sides of the valley is addressed; valley length is about 10 miles. Quality of spoils water that would enter the alluvium was estimated from overburden saturated-paste-extract analysis done by the U.S. Bureau of Land Management and Bureau of Reclamation for an EMRIA study of the Prairie Dog Creek area on the west side of the Tongue River valley. Analyses of cores from eight holes were used; the top 50 feet of overburden at each hole was considered to be the material that eventually would be at the bottom of hypothetical mine pits, and would therefore be the controlling factor of postmining water quality. This assumption generated by-far worst-case conditions because in all cores the upper 50 feet of material contained substantially higher soluble salts than did deeper materials. Average specific conductance of the top 50 feet of materials in the 8 cores is 5,530 µmhos/cm; SAR calculated from the average sodium, calcium, and magnesium concentrations is 6.6.

Postmining ground water flowing through the spoils would have a specific conductance equal to the premining specific conductance (estimated 3,300 µmhos/cm) plus that contributed by the spoils (5,530 µmhos/cm). Imput to the mass-balance equation is 5,530 µmhos/cm, representing an increased salt concentration due to hypothetical mining.

Sector II

This part of the petition area is that which lies east of the Tongue River where the river is the Reservation boundary. Valley reach is about 25.5 miles.

Mining only the east side of the valley is addressed. Quality of hypothetical spoils water was estimated by the same methods used for Sector I. Analyses from 69 cores (Montco, 1981, v. 23) have an average specific conductance of 4,730 µmhos; average SAR is 14.3.

Sector III

This is the downstream reach of the valley in the petition area, and extends from Sector II about 9 miles northward to the end of the petition area. Mining both sides of the valley is addressed. No data on available salt content in overburden are available, so input to the postmining mass-balance equation is the same as that for Sector II, 4,730 µmhos/cm.

Results

1. Changes in specific conductance (ΔSC):

The mass balance equation was applied in two ways. The premining system shows no cumulative effect of downstream inflow from bedrock aquifers, so the analysis was first performed to simulate no cumulative effects of inflow from mined lands. The implied changes in SC values over existing ones are listed below:

Sector I	2090 µmhos/cm (increase)
Sector II	920 µmhos/cm (increase)
Sector III	1770 µmhos/cm (increase)

The second analysis acknowledged the possibility of cumulative downstream effects. The equation was solved for 1-mile increments down the Tongue River Valley. For each successive increment, SC changes from preceding increments were input at the assumed down-river flow rate in the alluvium (20,000 ft^3/day). Results are plotted on attachment 2.

2. Sodium adsorption ratio (SAR):

SAR values are ratios, and therefore cannot be averaged and then balanced. Some indication, however, of the changes in SAR in the alluvial water can be obtained by comparing relative values. Most SAR values in the alluvium are less than 5. SAR values in other ground waters currently discharging to the alluvium are much higher; an estimated average is about 36. The spoils waters will contain increased percentages of calcium and magnesium relative to sodium, and will have SAR values generally less than 20. The resulting combining of the three types of water should not substantially increase the SAR values to more than about 10 in most alluvial waters.

Discussion

Validity of the analysis must be considered in light of the highly simplistic equation used, and its sensitivity to the input factors. The equation assumes uniformity over the entire area, which is certainly not the case. In reality, there probably are conditions in places along the valley that might cause higher postmining SC values than those calculated, and conditions in other places that would allow no change in alluvial-water quality.

Input parameters have various effects on the calculations. The rate of flow in alluvium parallel to the river (estimated 10,000 ft^3/day) is not a major factor in the analysis where no postmining change in SC with downstream distance is assumed. Where change is assumed, different flow rates will give different rates of SC change, but the ultimate increases will be similar.

Flow rates from coal and overburden aquifers (and subsequently from hypothetical mine spoils) significantly affect the results. For example, doubling them increases the calculated SC changes by about one-third. In reality, flow rates are probably substantially higher than the estimated 5,000 ft^3/day/side in some places, and substantially less in others.

Hypothetical spoils water quality is a very significant input to the calculations; predicted changes of SC in alluvial waters vary directly with the spoils-water SC. Those used in the analysis, 5,530 and 4,730 µmhos/cm, appear reasonably representative for the upstream two-thirds of the area; there is no indication of spoils-water SC for the downstream third. Strongly weighting the results toward higher SC values is the presumption that the upper 50 feet of overburden would become the saturated portion of future spoils. In all core analyses examined, the uppermost materials contained far more soluble salts than did lower materials.

Recharge from surface and other unspecified sources, estimated 0.25 ft/yr or 14,500 ft^3/day/mi, could easily be double that; predicted SC increases in alluvial water would then average about two-thirds of those calculated.

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Acknowledging the frailties of the mass-balance approach and its sensitivities to various inputs, the calculated changes in water quality should be treated only as a generality. Application to real proposed mines without highly specific data would more than likely give strongly misleading results.

Attachment 1

Parameter	Symbol	Input value(s)
Qal inflow rate	A	20,000 ft^3/day
Qal inflow SC (premining)	B	
Recharge	E	14,500 ft^3/day/mi
Bedrock inflow rate	F	10,000 ft^3/day/mi
Bedrock inflow SC	C	3300 µmhos/cm
Qal outflow rate	A+E+F	20,000 ft^3/day + 24,500 ft^3/day/mi
Qal outflow SC (premining)	D	
Qal inflow SC (postmining)	b	
Bedrock plus spoils SC (postmining)	c	8,830 µmhos/cm, 8,030 µmhos/cm
Qal outflow SC (postmining)	d	

Premining = Postmining

$$\frac{(A + E + F)D - AB - FC}{E} = \frac{(A + E + F)d - Ab - Fc}{E} .$$

$$\Delta SC = d - D = \frac{A(b - B) + F(c - C)}{A + E + F} .$$

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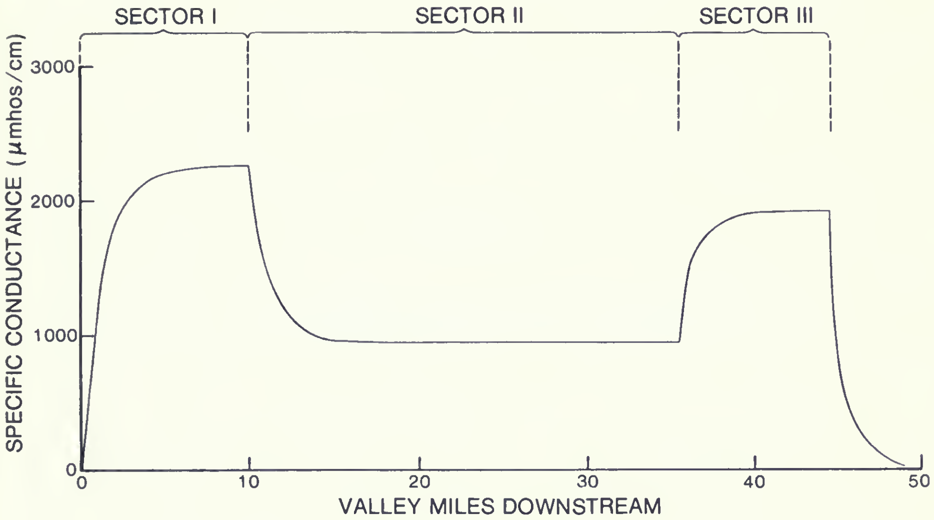
Attachment 2



APPENDIX E.

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS FOR UPPER 50 FEET OF OVERBURDEN

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR UPPER 50 FEET OF OVERBURDEN

Date sampled (number of samples)	Reach	Core recov-ered (feet)	Field EC (µmhos/cm)	Na	Ca	Mg	SAR ratio	Source of Data
				(mg/L)				
April 1977	1	42.5	2.7	7.2	5.0	22.4	2.63	BLM D4-78-102
April 1977	1	28	2.4	10.5	4.4	12.4	3.86	BLM D4-78-103
April 1977	1	40	6.5	49.1	11.3	20.0	12.41	BLM D4 78-105
April 1977	1	49.7	5.7	30.7	7.7	32.8		BLM D4 79-108
April 1977	1	50	8.6	47.7	19.0	45.2		BLM D4 79-109
April 1977	1	49.2	6.8	21.6	16.1	65.9		BLM D4 79-111
April 1977	1	50	5.0	16.8	13.2	42.4		BLM D4 79-112
	2	40	3.1	12.2	9.1	20.7	1.73	4449-1 Montco Permit Application
	2	50	5.3	38.6	9.2	22.4	9.71	4449-2C Montco Permit Application
	2	50	4.7	55.2	1.6	4.7	31.10	4449-3C Montco Permit Application
	2	50	4.4	40.3	4.0	18.6	11.99	4449-4C Montco Permit Application
	2	50	4.7	47.3	3.8	15.2	14.07	4449-5C Montco Permit Application
	2	50	6.9	69.6	6.7	14.0	21.63	4449-6C Montco Permit Application
	2	50	2.2	13.3	5.6	11.1	4.6	4449-7C Montco Permit Application
	2	38	3.5	4.0	1.0	3.6	2.64	4449-70BC Montco Per-mit Application
	2	50	3.8	24.5	8.6	20.3	6.45	4449-12B Montco Permit Application
	2	30	0.4	0.8	0.8	3.0	0.58	4449-16B Montco Permit Application
	2	25	0.9	5.5	0.8	2.8	4.10	4449-16D Montco Permit Application
	2	50	4.2	29.4	4.6	21.4	8.15	4449-17B Montco Permit Application
	2	50	1.8	11.0	2.1	7.2	5.10	4449-19W Montco Permit Application
	2	50	1.1	4.8	2.5	3.8	2.70	4449-20 Montco Permit Application
	2	50	6.6	52.0	8.9	19.1	13.90	4449-21 Montco Permit Application
	2	50	6.0	47.2	9.4	17.9	12.78	4449-22 Montco Permit Application
	2	40	7.4	55.6	20.3	21.9	12.10	4449-23C Montco Permit Application
	2	50	6.1	34.3	22.6	29.8	6.70	4449-26C Montco Permit Application

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR UPPER 50 FEET OF OVERBURDEN

Date sampled (number of samples)	Reach	Core recovered (feet)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data
	2	50	1.9	5.1	8.1	7.3	1.84	44431-OW1 Montco Permit Application
	2	50	5.6	26.2	27.0	31.9	4.83	44431-5C Montco Permit Application
	2	50	2.2	13.8	4.2	8.1	5.57	44431-7C Montco Permit Application
	2	20	2.4	5.7	12.4	9.4	1.73	44431-10 Montco Permit Application
	2	50	10.9	87.4	25.2	42.5	15.02	44431-12 Montco Permit Application
	2	47	7.0	56.8	12.6	26.3	12.88	44431-13C Montco Permit Application
	2	50	4.5	41.4	4.3	3.1	21.52	44436-3C Montco Permit Application
	2	50	4.5	27.1	10.7	26.8	6.26	44336-4C Montco Permit Application
	2	40	5.2	27.0	11.4	31.4	5.84	44336-40BC Montco Permit Application
	2	50	6.7	43.7	17.4	39.0	8.23	44336-5 Montco Permit Application
	2	45	2.9	17.3	5.3	12.0	4.68	44336-8 Montco Permit Application
	2	50	3.0	20.1	4.6	16.6	6.17	44336-10C Montco Permit Application
	2	50	10.0	93.8	15.8	27.4	20.18	44336-11C Montco Permit Application
	2	50	5.7	49.5	6.6	14.9	15.10	44336-16C Montco Permit Application
	2	50	3.1	15.0	8.9	14.4	4.40	44336-18 Montco Permit Application
	2	50	2.8	19.3	4.0	6.7	8.34	44336-20 Montco Permit Application
	2	50	3.5	22.7	13.9	16.9	5.78	44335-3C Montco Permit Application
	2	50	3.0	26.1	3.9	4.6	12.66	44335-5C Montco Permit Application
	2	50	6.2	47.9	13.6	24.8	10.93	44-3358RC Montco Permit Application
	2	50	4.2	35.2	8.6	13.1	10.69	44416-1 C Montco Permit Application
	2	8.5	3.7	27.3	4.9	10.8	8.50	44416-1C Montco Permit Application
	2	50	6.5	43.4	16.8	22.0	9.85	44416-4 Montco Permit Application

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR UPPER 50 FEET OF OVERBURDEN

Date sampled (number of samples)	Reach	Core recovered (feet)	Field EC (µmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	Source of Data
	2	50	1.6	13.1	0.1	2.5	11.49	44416-15 Montco Permit Application
	2	50	6.4	42.2	16.6	29.4	8.80	44416-14 Montco Permit Application
	2	50	7.6	59.7	9.7	24.1	14.52	44429-1C Montco Permit Application
	2	50	6.1	60.1	5.2	8.4	23.05	44431-3C Montco Permit Application
	2	50	5.6	58.2	6.4	19.3	16.24	54310-1C chip Montco Permit Application
	2	40	4.7	35.8	11.6	15.6	9.71	54317-4RC chip Montco Permit Application
	2	50	4.6	77.4	7.9	8.5	27.03	54320-2C chip Montco Permit Application
	2	49.1	3.2	29.6	7.7	7.6	10.70	3643-E
	2	50	4.2	20.3	9.7	17.2	5.54	3645-E
	2	50	6.0	25.6	10.8	20.9	6.43	3646-E
	2	50	4.2	27.5	15.0	24.0	6.23	3647-E
	2	50	3.2	17.3	2.8	5.0	8.76	3648-E
	2	50	5.6	39.6	6.6	12.5	12.81	3649-E
	2	50	3.6	13.2	3.3	2.6	7.69	3650-E
	2	50	8.6	39.8	6.4	6.0	15.98	3651-E
	2	32.8	6.3	35.3	9.9	10.2	11.14	3653-E
	2	50	8.7	57.6	19.9	34.2	11.08	3654-E
	2	43.6	3.4	13.2	9.5	16.4	3.67	3655-E
	2	50	2.6	13.4	4.9	7.9	5.30	3656-E
	2	50	13.4	142.2	28.2	25.5	27.44	3657-E
	2	50	8.4	38.0	5.4	7.4	15.02	3658-E
	2	50	7.1	33.2	5.8	11.9	11.16	3659-E
	2	50	3.9	33.3	4.8	8.9	12.72 (21.9)	3660-E
	2	40.2	6.2	33.3	2.2	4.0	18.91	3662-E
	2	50	1.9	6.3	5.6	5.7	2.65	3663-E
	2	50	1.8	11.0	0.8	1.4	10.49	3664-E
	2	37.3	4.6	62.4	4.4	7.4	25.69	54310-1C core
	2	35.5	3.9	39.5	1.1	2.2	30.75	54317-4RC core
	2	24	6.9	53.5	1.0	1.5	47.85	54320-2C core

SPECIFIC CONDUCTANCE AND SODIUM ADSORPTION RATIOS
FOR UPPER 50 FEET OF OVERBURDEN COLLECTED
BY OSM IN APRIL 1981

Depth-Weighted, Mean								
Date of Collection	Reach	Hole depth	Field EC (μmhos/cm)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	SAR ratio	OSM Field No.
April 25, 1981	Otter Creek	50	6,260	53.9	7.9	18.1	14.9	A-1
April 28, 1981	1	50	6,070	35.3	10.3	30.5	7.8	3
April 28, 1981	1	30	8,430	69.2	8.1	31.1	15.6	5
April 28, 1981	1	50	3,980	20.2	6.9	19.2	5.6	6
April 28, 1981	2	50	7,600	66.1	6.2	17.1	19.3	7
April 26, 1981	2	50	8,040	49.4	11.1	53.4	8.7	8
April 26, 1981	2	50	4,360	33.3	3.9	6.4	14.7	9(A)
April 21, 1981	3	30	3,750	14.9	13.1	16.7	3.8	20
April 22, 1981	3	50	3,550	17.7	8.8	13.9	5.2	22
April 21, 1981	3	35	5,470	38.7	10.5	21.6	9.7	23
April 23, 1981	3	50	2,890	7.6	14.2	11.1	2.1	23A
April 21, 1981	3	50	710	2.1	2.0	2.4	1.4	24
April 21, 1981	3	20	480	1.6	2.6	1.5	1.08	25A
April 21, 1981	3	50	1,470	3.2	5.9	6.7	1.3	25B
April 22, 1981	3	25	4,400	24.1	11.9	14.9	6.6	26
April 23, 1981	3	50	540	2.9	2.0	1.3	2.3	26B
April 25, 1981	3	50	240	1.0	1.2	1.4	0.9	27
April 22, 1981	3	--	----	---	---	---	---	29
April 26, 1981	Otter Creek	50	1,940	16.3	1.0	4.1	10.2	30
April 25, 1981	3	50	6,100	59.8	5.4	5.5	25.6	31
April 27, 1981	Otter Creek	50	3,460	32.4	4.2	3.4	16.7	36
April 25 & 26 1981	3	45	3,610	11.3	10.2	17.7	3.0	38A
April 23, 1981	3	--	----	---	---	---	---	40
April 23, 1981	3	--	----	---	---	---	---	41A
April 23, 1981	3	--	----	---	---	---	---	41B
April 24, 1981	3	--	----	---	---	---	---	42
April 24, 1981	3	--	----	---	---	---	---	43
April 25, 1981	3	--	----	---	---	---	---	50
April 26, 1981	3	--	----	---	---	---	---	54
April 25, 1981	3	--	----	---	---	---	---	55
April 27, 1981	Otter Creek	--	----	---	---	---	---	60
April 27, 1981	Otter Creek	--	----	---	---	---	---	61
April 27, 1981	Otter Creek	--	----	---	---	---	---	62
April 25, 1981	Otter Creek	--	----	---	---	---	---	141
April 25, 1981	Otter Creek	--	----	---	---	---	---	142

Summary	EC
Reach 1	5.68
2	4.99
3	4.19
Otter Creek	3.89